10-2005

Segment Analysis Of Fish Creek The Location Of Sources Of Pollution

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SEGMENT ANALYSIS OF
Fish Creek

The Location of Sources of Pollution

Part of the Lake Ontario Watershed
Located in Orleans County, New York

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Funded by the Orleans County Soil and Water Conservation District

October 2005

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SUMMARY

The Orleans County Soil and Water Conservation District has monitored the waterways of Orleans County since 1997 in collaboration with the State University of New York at Brockport's Department of Environmental Science and Biology (1,2,3,4,5). SUNY Brockport has provided analytical services for water chemistry, consulting services on the direction of the monitoring program and interpretation of data. In 2004, the Orleans County Soil and Water Conservation District and the Orleans County Water Quality Coordinating Committee expanded efforts to identify sources of water pollution within the County by focusing on Fish Creek. The goal was to identify the sources of nutrients, soils and salts within the Fish Creek watershed beginning in the fall of 2004. Fish Creek is located in the south portion of the Lake Ontario watershed, Orleans County, New York and flows into Oak Orchard Creek south of Route 104 and east of Bates Road in the Town of Ridgeway, New York. To accomplish the goal, point and non-point sources were identified through a process called segment analysis.

In this report, we provide evidence indicating the pollutants and identify the location and the intensity of pollution sources in the Fish Creek watershed. What follows is a synopsis of what pollutants are being lost and where the sources are located.

Twelve areas in the Fish Creek watershed were identified as sources of nutrients (phosphorus and nitrogen), soils or sodium. Maps, including a summary map (Figure 2, page 26), are included in the text to locate these areas.

1. **Site 2 on Portage Road downstream to Site 1 on Scott Road (source of total phosphorus, total Kjeldahl nitrogen and total suspended solids)**
2. **Site 3 on Culvert Road downstream to Site 2 on Portage Road (source of total phosphorus, total Kjeldahl nitrogen and total suspended solids). See Illustration 1, page 22.**
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10. Upstream of site 17S on Townline Road (source of soluble reactive phosphorus)

11. Upstream of Site 18 on West Lee Road (source of nitrate and total Kjeldahl nitrogen)

12. Upstream of site 14 on Martin Road and downstream of site 15 (source of soluble reactive phosphorus)

13. Upstream of site 15 on Bigford Road (source of total Kjeldahl nitrogen and sodium)

RECOMMENDATIONS

1. Likely locations of sources of elevated levels of nutrients and soil loss are identified. A visual inspection of these areas with landowners is suggested to pinpoint potential sources.
2. In general, control of water movement can be a means of significantly reducing non-point source pollution, whether it be nutrients or soil. Since water must come in contact with the nutrient or soil source and then be transported to the surface (or subsurface) water body, the nutrients in our streams and lakes are functions of land use practices, soil fertility and quantities of transporting water. Management practices, which reduce the magnitude of surface runoff, are recommended to decrease the magnitude of soil and chemical losses from land areas. Management practices such as buffer strips, sediment retention ponds, contour plowing, timing of tillage practices and timing of manuring practices, where used, all can either reduce the erosive power of water running across the landscape or reduce the potential of nutrient and soil loss.
3. Identified point and non-point sources of nutrients and solids can be remediated using Best Management Practices (BMP). This would necessitate working with the Water Quality Coordinating Committee and various users to assist them in their stewardship of the land they own.
4. There are two primary categories that the identified sources for Fish Creek fall into, stream bank erosion and agriculture. BMPs can be targeted for each of these specific categories.

a. For example, the steep sided stream banks that are characteristic of portions of Fish Creek can be vegetated with plants that thrive in this area and form root structures that help prevent erosion into the stream. Farming practices can and should be reviewed at all the identified agricultural sources of pollution to Fish Creek.

b. Farm and land management programs (e.g., Agricultural Environmental Management) already exist and are ably sponsored through county Soil and Water Conservation Districts and Cornell Cooperative Extension. Efforts, if not already in place, should be made to expand existing programs or initiate new programs to reduce/remediate areas identified in this study. Recent work on croplands and dairy farms in the Conesus Lake watershed have demonstrated how nutrient and soil loss can be maintained on farm run while potentially saving money for the farmer (18)(Appendix A, page 49).

Also, much of the loss of nutrients in the Fish Creek watershed was in the dissolved form as nitrate and phosphorus. Information on nutrient management in agriculture settings in New York State is reviewed in a recent issue of Northeast Dairy Business and is applicable to other crops. For example, articles titled “Nine Tips to Manage N Better” (19) and “How Much P is Enough” (20) provide a useful review of nutrient management issues that are applicable to the Fish Creek watershed. Farmers in western New York have reduced fertilizer usage and successfully maintained corn yields while saving money. Also, the high losses of sodium during the summer from some fields is likely do to the use of potash and not deicing salt.

INTRODUCTION

The Orleans County Soil and Water Conservation District has monitored the waterways of Orleans County since 1997 in collaboration with the State University of New York at Brockport's Department of Environmental Science and Biology. Monitoring efforts have included the installation of a permanent gauging and sampling stations located on Johnson Creek, Sandy Creek and Oak Orchard Creek (1, 2). The District and SUNY Brockport have also completed a Stressed Stream Analyses on Johnson Creek in 2000 (3), Marsh Creek in 2001 (4) and Otter Creek in 2003 (5). SUNY Brockport has provided analytical services for water chemistry, data interpretation, as well as consulting services on the direction of the monitoring program.

Fish Creek is located in the southern portion of the Lake Ontario watershed, Orleans County, New York, and flows into Oak Orchard Creek south of Route 104 and east of Bates Road in the Town of Ridgeway, New York (Fig. 1). The goal of this project was to identify the sources of nutrients, soils and salts within the Fish Creek watershed through a process called segment analysis (6). With this report, we provide evidence suggesting the location, identity of pollutants and the intensity of pollution sources in the Fish Creek watershed.

The Approach:
Point and non-point sources of nutrients, soils and salts were identified through a process called segment analysis (6). Segment analysis, a subset of a process called stressed stream analysis, identifies impacted sub-watersheds and their associated streams (3,4,5,6,7,8,9,10,11,12). Within a subwatershed, stressed stream analysis is an approach for determining how and where a stream and its ecological community are adversely affected by a pollution source or other disturbances. Stressed stream analysis is an integrative, comprehensive approach for determining the environmental health of a watershed and its constituent streams. It is a technique that identifies the sources, extent, effects and severity of pollution in a watershed. In its fullest use, it combines elements of the sciences of hydrology, limnology, ecology, organismal biology and genetics in an integrated approach to analyze cause and affect relationships in disturbed stream ecosystems.

Within a sub-watershed, the stream is used to monitor the "health" of the watershed. Because nutrients are easily transported by water, they can be traced to their source by systematic geographic monitoring of the stream. Segment analysis is a technique that divides the impacted sub-watershed into small distinct geographical units – segments. Samples are taken at the beginning and end of each segment of the stream to determine if a nutrient source occurs within that reach. At completion, the cause and extent of pollution have been identified. If needed, the severity of the pollution within the impacted sub-watershed and or the entire watershed can then be evaluated by spatial analysis of the quantity and quality of biological indicators, such as fish and invertebrates, and by biological examination of structural and functional changes in individual organisms and populations in affected communities. Once identified, sources of chemical pollutants may be corrected using "Best Management Practices" (BMP). In this report, stressed stream analysis is limited to a spatial analysis of chemical sources of Fish Creek.

DEFINITIONS

Total Phosphorus- A measure of all forms of the element phosphorus. Phosphorus is an element required for plant growth on land or in water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction, of lakes. Phosphorus may enter a watershed in soluble or organic form from several sources including sewage, heavy-duty detergents, fertilizer and agricultural waste. Some forms of phosphorus are more available to, and cause increase productivity, in plants.

Soluble Reactive Phosphorus- A measure of the most available and active form of phosphorus (PO_4^{3-}).

Nitrate + Nitrite- A measure of the soluble forms of nitrogen (NO_2^{2-}, NO_3^-) used readily by plants for growth. Sources of nitrates in the environment are many and include barnyard waste and fertilizer.

Total Kjeldahl Nitrogen- The Kjeldahl method is a convenient method of analysis for nitrogen but cannot be used for all types of nitrogen compounds. It is, however, a good measure of organic nitrogen, including ammonia. Manure, for example, contains a large amount of organic nitrogen.

Sodium- A measure of the mineral salt, most commonly found as sodium chloride (NaCl), and dissolved in water. NaCl naturally occurs in deep layers of local bedrock. Mined, it is stored and spread as a de-icing agent on roads and other pavements.

Total Suspended Solids - A measure of the loss of soil and other materials suspended in the water from a watershed. Water-borne sediments act as an indicator, facilitator and agent of pollution. As an indicator, they add color to the water. As a facilitator, sediments often carry other pollutants, such as nutrients and toxic substances. As an agent, sediments smother organisms and clog pore spaces used by some species for spawning.

SAMPLING AND ANALYTICAL METHODS

Segment analysis was performed on seven dates on Fish Creek (9 September 2004, 14 September 2004, 8 December 2004, 4 January 2005, 15 February 2005, 4 April 2005 and 31 August 2005). Sampling locations are shown on Figure 1, road locations and latitude and longitude are presented in Table 1. All samples were analyzed for nitrate, soluble reactive phosphorus, total phosphorus, total Kjeldahl nitrogen, sodium, and total suspended solids. James Kingston, Nichelle Billhardt, Judy Bennett, and Dan Schuth of the Orleans County Soil and Water Conservation District completed the field sampling. Early in the segment analysis process, the stream is divided into geographical units and sampled at easily accessible locations where the stream crosses roads. Initially, a non-event and a runoff event are sampled and as elevated levels of pollutants are identified the sampling regime is expanded to further pinpoint pollution sources.

During the initial segment analysis on 9 September 2004, seven stations were sampled under event conditions covering the major segments of the tributary (Figure 1, Tables 1 and 2). On 14 September 2004, the same seven stations (sites) sampled on the previous date were sampled under non-event conditions (no discernable rainfall for several days before sampling) (Table 2). The same seven stations were sampled during event conditions on 8 December 2004 and 4 January 2004. Based on these analyses, stations were added to the segment analysis to further pinpoint sources of pollution identified during the first four sampling events. The areas that were further investigated were between Scott Road south to Culvert Road (between site 1 and site 3), east and southeast of Wood Road (site 7), south of Wheeler Road (site 17), and south of Martin Road (site 14). All samples were generally taken within 180 minutes. Specific locations of all sampling sites are shown in Figure 1.

All sampling bottles were pre-coded so as to ensure exact identification of the particular sample. All sample bottles were routinely cleaned with phosphate free RBS between sampling dates. Containers were rinsed prior to sample collection with the water being collected. Grab samples were taken from the subsurface waters in a well-mixed area of the stream. In general, all procedures followed EPA standard methods (13) or Standard Methods for the Analysis of Water and Wastewater (14). Sample water for dissolved nutrient analyses (SRP, nitrate + nitrite) was filtered immediately with 0.45-µm MCI Magna Nylon 66 membrane and either frozen or analyzed within 24 hours of collection.

Nitrate+Nitrite: Analysis for dissolved nitrate+nitrite nitrogen was performed by the automated (Technicon autoanalyser) cadmium reduction method (14).

Soluble Reactive Phosphorus: Sample water was filtered through a 0.45-µm membrane filter. The filtrate was analyzed for orthophosphate using the automated (Technicon) colorimetric ascorbic acid method (14). The formation of the phosphomolybdeum blue complex was read colorimetrically at 880nm.

Total Phosphorus: The persulfate digestion procedure was used prior to analysis by the automated (Technicon autoanalyser) colorimetric ascorbic acid method (14).

Total Kjeldahl Nitrogen: Analysis was performed using a modification of the Technicon Industrial Method 329-74W/B. The following modifications were made:

- In the sodium salicylate-sodium nitroprusside solution, sodium nitroprusside was increased to 0.4 gm/L.
- The reservoir of the autoanalyzer was filled with 2M H_2SO_4 instead of distilled water.
- Other reagents were made fresh prior to analysis.

Sodium: Sodium analysis was performed by Atomic Absorption Spectrophotometry (14).
Total Suspended Solids: APHA (14) Method 2540D was employed for this analysis.

QUALITY CONTROL

The Water Chemistry Laboratory at SUNY Brockport is certified through the New York State Department of Health's Environmental Laboratory Approval Program (ELAP - # 11439). This program includes bi-annual proficiency audits, annual inspections and good laboratory practices documentation of all samples, reagents and equipment (Table 3).

RESULTS

All sampling dates experienced precipitation both on the dates of sampling and the day previous with the exception of 14 September 2004, which was a non-event sample (Table 2). The largest amounts of precipitation occurred around the 9 September 2004, 4 April 2005 and 31 August 2005 sampling dates. On 15 February 2005 and 4 April 2005, the study area experienced relatively high temperatures and significant snowfall within the prior week causing additional overland flow due to snow melt. The results of all analyses are presented in Table 4 while Figures 3 through 23 show each individual water quality parameter for each sampling date presented geographically on a Fish Creek watershed map. A summary map of identified point and non-point sources is presented in Figure 2.

TOTAL PHOSPHORUS (Table 4, Figures 3, 6, 9, 12, 15, 18 and 21)

The initial two sampling efforts on 9 September 2004 and the non-event sample on 14 September 2004 suggested three areas of the Fish Creek watershed where losses of total phosphorus are occurring.

1. **Site 3 on Culvert Road downstream to site 1 on Scott Road:** There was an increase of 41% in total phosphorus concentration (570.7 to 805.6 µg P/L) moving downstream from site 3 (Culvert Road) to site 1 (Scott Road) on 9 September 2004 (Figure 3). A similar, but smaller increase (8%) occurred between these sites in the non-event sampling effort on 14 September 2004 (Figure 6). A significant increase in total phosphorus was not observed from site 3 downstream to site 1 for the sampling trips in December 2004 and January 2005 (Figures 9 and 12). This suggests an intermittent source of total phosphorus exists between these two sites. To further pinpoint this source, an additional site was added (site 2 on Portage Road) between sites 3 and 1 beginning in February of 2005. On two of the dates that site 2 (Portage Road) was sampled (15 February 2005 and 4 April 2005), the pattern of total phosphorus increase between site 1 (Scott Road), site 2 (Portage Road), and site 3 (Culvert Road) was not consistent. On 15 February 2005 (Figure 15), total phosphorus concentrations increased 42.8% between site 3 (Culvert Road) downstream to site 2 (Portage Road) suggesting a source between these sites. There was no further increase in total phosphorus (in fact there was a decrease in TP concentration) between site 2 (Portage Road) downstream to site 1 (Scott Road) on 15 February 2005 (Figure 15). On 4 April 2005 (Figure 18), total phosphorus concentrations varied within one microgram per liter between site 2 (Portage Road) and site 3 (Culvert Road), but increased by 32.5% between site 2 (Portage Road) downstream to site 1 (Scott Road). This result suggests a phosphorus source between sites 1 and 2 on 4 April 2005. Clearly, there are multiple sources in the reach of Fish Creek between site 3 on Culvert Road and site 1 on Scott Road that appear at different times of the year. The land use between site 3 on Culvert Road and site 1 on Scott Road is a mix of cropland and orchard with a wooded buffer along the stream although the stream banks are steep in this area with varying amount of vegetative cover on them leaving a potential for erosion into the creek. **). See Illustration 1, page 22.**
2. **Upstream of site 17 on Wheeler Road:** Site 17 on Wheeler Road had second highest total phosphorus concentration found on 9 September 2004 (599.3 µg P/L – Figure 3) and

the highest TP concentration found on 14 September 2004 (187.3 µg P/L – Figure 6) suggesting a source of total phosphorus upstream of site 17. Similarly on 4 January 2005 (Figure 12), TP concentrations at site 17 were elevated but this was not the case on 4 December 2004 (Figure 9). Two additional sites were added upstream of site 17 beginning on 15 February 2005 to further identify the TP source in this reach of Fish Creek. On 15 February 2005 and 4 April 2005 site 17N (Town Line Road South) was higher in total phosphorus concentration than site 17S (Town Line Road North) (Figures 15 and 18). This suggested that the TP source was in the 17N reach and an additional site (site 17NE) was added upstream of site 17N for the 31 August 2005 sampling effort. The results for site 17NE show an incredibly high level of total phosphorus at 2169.3 µg P/L (Figure 21). This site is characterized by cropland, orchards and woods and will be discussed further in the Summary section of this report.

3. **Upstream of site 7 on Wood Road**: On the initial sampling event on 9 September 2004, site 7 on Wheeler Road had the fourth highest total phosphorus concentration (495.6 µg P/L) for that date (Figure 3). This was not the case for the non-event sampled on 14 September 2004, where the TP concentration at site 7 was relatively low (53.8 µg P/L) (Figure 6). Similarly, TP was not elevated at site 7 on 8 December 2004 (57.9 µg P/L, Figure 9) and on 4 January 2005 (79.6 µg P/L, Figure 12). However, two additional sites (site 8 on Long Bridge Road and site 9 on County House Road) were added upstream of site 7 beginning on 15 February 2005 to help characterize the intermittent source of TP upstream of site 7 (Figure 1). Results show that site 8 on Long Bridge Road had the second highest TP concentration on 15 February 2005 (Figure 15) and the third highest TP concentration on 4 April 2005 (Figure 18). This suggests that there is a source of total phosphorus in the reach of Fish Creek upstream of site 8 (Figure 2). On the 31 August 2005 sampling event, site 8 had an unremarkable TP concentration of 197.4 µg P/L, the eleventh highest value found in Fish Creek on that date. The area of Fish Creek upstream of site 8 collects drainage ditches from predominantly agricultural land (cropland for a dairy farm and vegetable farm) with some residential and woodland. Land use will be discussed further in the Summary section of this report.

SOLUBLE REACTIVE PHOSPHORUS (Table 4, Figures 3, 6, 9, 12, 15, 18 and 21)

All seven sites sampled on the initial sampling trip were relatively high in soluble reactive phosphorus (SRP) (over 90 µg P/L) due to overland runoff. The highest concentration on 9 September 2004 was found at site 17 on Wheeler Road (311.8 µg P/L) with additional high levels of SRP found at headwater sites: site 7 on Wood Road (262.0 µg P/L) and site 14 on Martin Road (160.7 µg P/L) (Figure 3). On 14 September 2004 (Figure 6), site 17 once again had the highest concentration of SRP in Fish Creek at 170.8 µg P/L nearly double the concentration of the next highest SRP concentration (site 14 [Martin Road] at 90.0 µg P/L) while site 7 on Wheeler Road was not as high (42.2 µg P/L) for this sampling during non-event conditions. Similarly, on the third sampling trip (8 December 2004 – Figure 9), site 17 was 48% higher in SRP concentration than the next highest site on Fish Creek (47.2 µg P/L at site 3 on Culvert Road). The sampling trip on 4 January 2005 (Figure 12) did not show any remarkable soluble reactive phosphorus concentrations, the highest SRP concentration on this date was 59.4 µg P/L at both sites 3 (Culvert Road) and 1 (Scott Road). Clearly, sources of soluble reactive phosphorus were located at headwater streams of sites 17, 7 and 14.

1. **Upstream of site 17 on Wheeler Road:** There is a source of soluble phosphorus in the reach of Fish Creek upstream of Wheeler Road (Figure 2). To further pinpoint this source, two additional sites (17N and 17S both on Town Line Road – see Figure 1) were added beginning on 15 February 2005. On the first two dates that site 17N (Town Line Road South) and site 17S (Town Line Road North) were sampled (15 February 2005 [Figure 15] and 4 April 2005 [Figure 18]), site 17N was higher in soluble reactive phosphorus concentration than site 17S (~ 59 µg P/L versus ~26 µg P/L) suggesting the source of soluble reactive phosphorus in the 17N reach of Fish Creek. An additional site (site 17NE) was added upstream of site 17N for the 31 August 2005 sampling effort (Figure 21) and resulted in the highest soluble reactive phosphorus concentration recorded during this study at 788.0 µg P/L. This site is characterized by cropland, orchards and woods and will be discussed further in the Summary section of this report.

2. **Upstream of site 7 on Wood Road:** The two headwaters upstream of site 7 (Wood Road) are contributing soluble reactive phosphorus downstream to site 3 (Culvert Road) and is a source of SRP to the entire creek. Sites 8 (Long Bridge Road) and 9 (County House Road) were added to further identify the source of soluble reactive phosphorus in the site 7 reach of Fish Creek upstream of Wood Road. On two of the dates that sites 8 (Long Bridge Road) and 9 (County House Road) were sampled (15 February 2005 and 4 April 2005), site 8 was at least 211% greater in soluble reactive phosphorus concentration than site 9. The source of soluble reactive phosphorus in this reach of Fish Creek is the area upstream of site 8 (Figure 2) where the land use is cropland currently in soybeans, corn and cabbage.

3. **Upstream of site 14 on Martin Road:** There is a source of soluble reactive phosphorus upstream of site 14 on Martin Road. An additional site, site 15 on Bigford Road upstream of site 14, was added beginning with the 15 February 2005 sampling date (see Figure 1). On 15 February 2005 (Figure 15), site 14 (Martin Road) had a SRP concentration of 43.9 µg P/L while the upstream site (site 15 on Bigford Road) had a SRP concentration of 60.9 µg P/L, suggesting the source of SRP is upstream of site 15 on Bigford Road. Similarly on 4 April 2005 (Figure 18), SRP concentrations were higher at the upstream station on Bigford Road (39.6 µg P/L at site 15 versus 32.3 µg P/L at site 14) also suggesting the source is upstream of site 15. Conversely on 31 August 2005 (Figure 21), SRP increased 39% from 156.5 µg P/L at site 15 on Bigford Road downstream to site 14 on Martin Road where the SRP concentration was 216.9 µg P/L. This suggests an additional source in the reach of Fish Creek between Martin Road and Bigford Road. The land use in these areas is predominately agricultural row crops mixed with woodlands and will be discussed further in the summary section of this report.

SODIUM (Table 4, Figures 8, 11,14,17,20 and 23)

Sodium ranged from 0.5 mg/L at Site 14 on 9 September 2004 to 121.12 mg/L at Site 7 on 31 August 2005 (Table 4). The seven highest concentrations of sodium found in this study occurred on 31 August 2005, which is curious, because August is chronologically distant from the traditional sodium source in this area, deicing salt to treat frozen roads. There may be a connection with local agricultural practices and loss of sodium from the watershed. Segment analysis has identified three areas in the watershed as sources of sodium loss to Fish Creek.

1. **Upstream of site 7 on Wood Road including the area upstream of site 8 on Long Bridge Road and the area upstream of site 9 on County House Road:** Prior to 31 August 2005, the highest sodium concentration (30.67 mg/L) observed was found at site 7 (Wood Road) on 14 September 2004 (Table 4, Figure 8). As a result, sites 8 and 9 were added beginning in February 2005 to determine if a source could be identified upstream of site 7. On two of the dates (15 February 2005, Figure 17 and 4 April 2005, Figure 20) that site 8 (Long Bridge Road) was sampled, multiple sources in the area upstream of site 7 to site 8 were identified. For example on 15 February 2005 (Figure 17), site 8 was relatively high in sodium (15.10 mg/L) from the headwaters of that reach of Fish Creek but further increased to 20.75 mg/L downstream to site 7 (Figure 17). A similar situation existed on 4 April 2005 when sodium again increased from site 8 downstream to site 7 (Figure 20). This area is cropland in soybeans, cabbage and corn. In February and April 2005, site 9 on County House Road was low in sodium relative to site 8 on Long Bridge Road (Figures 17 and 20). This changed on 31 August 2005 when the source of sodium at Site 7 was upstream of site 9 on County House Road where the sodium concentration was 111.46 mg/L (Figure 23). The land use in this area is cropland currently in soybeans, corn and cabbage. As mentioned earlier, the high levels of sodium found on 31 August 2005 are not associated with de-icing salts applied to the roads.
2. **Upstream of site 18 on West Lee Road – Route 31A:** A source of sodium exists upstream of site 18 on Route 31A. Site 18 has the second highest concentration of sodium, 18.24 mg/L, on the 15 February 2005 sampling date (Figure 17). Site 18 also had the second highest concentration on two dates and the third highest sodium concentration found on an additional two sampling dates (Table 4). The land use in this area is primarily agriculture with land in cabbage and orchards. There currently is no concrete explanation for the high sodium concentrations observed, especially for the non-winter or snowmelt enhanced sampling dates. A connection with farming practices and sodium loss from the watershed should be explored.
3. **Roadside drainage into Fish Creek at site 3A on Culvert Road and site 11A on Route 31A:** Two additional sites that possessed high concentrations of sodium on 31 August 2005 were site 3A (94.40 mg/L) and site 11A (82.74 mg/L) (Figure 23). Both are roadside drainage pipes flowing into Fish Creek. These sources are puzzling because the end of August is well removed from the road de-icing salt season. Farmers have been using potash in the area to fertilize their crops (mainly orchards and cabbage). Potash typically contains around 2.25% sodium chloride and this may be the summer source of sodium in these areas.

NITRATE (Table 4, Figures 4,7,10,13,16,19 and 22)

Site 7 had the highest nitrate concentration on the first four sampling dates (Figures 4, 7, 10, 13). On two dates at Site 7 (Wood Road), the nitrate concentration exceeded the New York State Department of Environmental Conservation's ambient water quality guideline of 10 mg N/L

(19.42 mg N/L on 14 September 2004 and 14.60 mg N/L on 8 December 2004) (Figures 7 and 10). Site 18 on Route 31A had elevated nitrate concentrations suggesting a source in the first order reaches upstream of site 18 (Figures 4, 7, 10, 13). Site 10 on Dresser Road had elevated levels of nitrate on 14 September 2004 (7.07 mg N/L), 8 December 2004 (3.93 mg N/L) and 4 January 2005 (2.03 mg N/L). A portion of the creek flowing into site 10 comes from the reach of the stream represented by site 18 (and its source of nitrate), but there are other branches of Fish Creek that also feed into this site and an additional source of nitrate was discovered on one of them.

Additional sampling helped to pinpoint the sources of nitrate to Fish Creek upstream of sites 7, 18 and between sites 11 and 14.

1. **Site 7; upstream of site 7 on Wood Road including the area upstream of site 8 on Long Bridge Road and the area upstream of site 9 on County House Road:** Additional sites were added upstream of site 7 on 15 February 2005, 4 April 2005 and 31 August 2005 to determine the source of nitrate in this reach of Fish Creek. Results from this analysis suggest that a source of nitrate exists in both branches of Fish Creek upstream of site 7 on Wood Road. Site 8 on Long Bridge Road and site 9 (County House Road) had elevated levels of nitrate on both 15 February 2005 (site 8 – 3.20 mg N/L, site 9 - 3.91 mg N/L) (Figure 16) and 4 April 2005 (site 8 – 2.73 mg N/L, site 9 – 4.35 mg N/L) (Figure 19) when compared to site 7 on Wood Road. This suggests that the sources of nitrate are upstream, of site 8 on Long Bridge Road and upstream of site 9 on County House Road.

   On 31 August 2005, after a three inch rainfall, site 8 on Long Bridge Road, upstream of site 7, had a nitrate concentration of 44.12 mg N/L. Clearly this area is a source of nitrate upstream of site 8 on Long Bridge Road. The land use in this reach of Fish Creek is cropland for a dairy farm and a vegetable farm with some residential and wooded areas.
2. **Site 18; upstream of site 18 on Route 31A (West Lee Road):** A source of nitrate exists upstream of site 18 on West Lee Road where elevated concentrations of nitrate were observed on every sampling date. For example, the nitrate concentration at site 18 was 1.08 mg N/L on 9 September 2004, 5.94 mg N/L on 14 September 2004, 3.72 mg N/L on 8 December 2004, 3.69 mg N/L on 4 January 2005, 2.13 mg N/L on 15 February 2005, 4.19 mg N/L on 4 April 2005 and 11.30 mg N/L on 31 August 2005 (Table 4). A site upstream of site 18 was targeted for the 31 August 2005 sampling date but unfortunately there was no flow in this area even after three inches of rain.
3. **Site 14 on Martin Road downstream to site 11 on Route 31A:** The reach of Fish Creek characterized by site 14 on Martin Road had no remarkable nitrate concentrations (see site 14 on Table 4) and the high nitrate concentrations observed at site 10 on Dresser Road were attributed to the nitrate source in the site 18 reach (see above). On 31 August 2005, an additional site (site 11 on route 31A) was sampled in the site 14 reach of Fish Creek and an additional source of nitrate was identified. On 31 August 2005, there was a 139% increase in the concentration of nitrate from site 14 on Martin Road (5.82 mg/L) downstream to site 11 on Route 31A (13.90 mg/L) (Figure 22). The land use in this area is agricultural row crops mixed with woodlands. The likely source during this three inch precipitation event is the nitrate running off of the agricultural land.

TOTAL KJELDAHL NITROGEN (Table 4, Figures 4,7,10,13,16,19 and 22)

There are eight identified areas of Fish Creek that are sources of total Kjeldahl nitrogen (TKN) (Figure 2).

1. **Site 3 on Culvert Road downstream to site 1 on Scott Road:** The reach of Fish Creek that was consistently high in TKN concentration (9 September 2004, 14 September 2004, 4 January 2005, 15 February 2005, and 4 April 2005) is from site 3 on Culvert Road downstream to site 1 on Scott Road (Table 4). The highest total Kjeldahl nitrogen concentration (1860 µg N/L) was found at site 1 (Scott Road) on 9 September 2004 (Figure 4). Like total phosphorus, there is evidence of multiple sources of TKN in the reach of Fish Creek between site 3 (Culvert Road) downstream to site 1 (Scott Road) at different times of the year. For example, on 15 February 2005, there is a source of TKN between site 3 (1190 µg N/L) downstream to site 2 (1370 µg N/L) but no increase downstream to site 1 (1250 µg N/L) (Figure 16). Conversely on 4 April 2005, there was no increase in TKN concentration between site 3 (820 µg N/L) downstream to site 2 (820 µg N/L) but there was a source evident from site 2 (820 µg N/L) downstream to site 1 (910 µg N/L) (Figure 19). The land use between site 3 on Culvert Road and site 1 on Scott Road is a mix of cropland and orchard with a wooded buffer along the stream although the stream banks are steep in this area with varying amount of vegetative cover on them leaving a potential for erosion into the creek. **See Illustration 1, page 22.**
2. **Upstream of site 18 on Route 31A, upstream of site 11 on Route 31A and site 11A, the roadside ditch along route 31A adjacent to site 11:** On several dates (8 December 2004 [Figure 10], 15 February 2005 [Figure 16], and 4 April 2005 [Figure 19]) site 10 (Dresser Road) had a higher total Kjeldahl nitrogen concentration than the sites immediately upstream. This suggests a source of TKN in this reach that was identified by adding additional sampling sites between site 10 (Dresser Road) and the sites upstream (site 14 Martin Road; site 17 Wheeler Road; and site 18, West Lee Road) on 31 August 2005 (Figure 22). The major contributor of TKN to site 10 on 31 August 2005 was the reach of the stream represented by site 18 (1290 µg N/L), followed by the reach covered by site 11 (1120 µg N/L) and the roadside drainage ditch at site 11A (1200 µg N/L) (Figure 22). The land use represented by site 18 on Route 31A is primarily agriculture with land in cabbage and orchards. Agriculture is also the primary land use for site 11.
3. **Upstream of site 8 on Long Bridge Road and upstream of site 9 on County House Road:** Site 7 had the third highest TKN concentration on the initial sampling date (1520 µg N/L on 9 September 2004, Figure 4) and the fourth highest TKN concentration on 14 September 2004 (610 µg N/L, Figure 7). Two additional sites (site 8 on County House Road and site 9 on County House Road) were added to further pinpoint the source of TKN in this reach of Fish Creek beginning in February 2005. At site 9, TKN concentrations of 1070 and 1170 µg N/L were observed on 4 April 2005 (Figure 19) and 31 August 2005 (Figure 22), near the headwaters of Fish Creek, suggesting a source in that immediate area (see Figure 2). The land use upstream of site 9 on County House Road is cropland that was in soybeans, corn and cabbage. Similarly, the cropland upstream of site 8 on Long Bridge Road was a source of total Kjeldahl nitrogen (1720 µg N/L) on 31 August 2005 (Figure 22). **See Illustration 1, page 22.**
4. **Upstream of site 15 on Bigford Road:** Site 15 on Bigford Road was added on 15 February 2005 to help identify the source of TKN found at site 14 (Martin Road) on 14 September 2004 where is was the highest TKN concentration found on that date (Figure 7). On two dates (15 February 2005 and 31 August 2005), the western headwater site 15

on Bigford Road had elevated total Kjeldahl nitrogen concentrations when compared to the other sites sampled on Fish Creek (Figures 16 and 22). There is a large wooded buffer around Fish Creek in the area upstream of site 15 that slows and absorbs runoff from the agricultural land that surrounds it. Apparently the buffer is not keeping out all the agricultural runoff from making it to the stream especially during large runoff events such as 15 February and 31 August 2005.

TOTAL SUSPENDED SOLIDS (Table 4, Figures 5,8,11,14,17,20 and 23)

On the initial sampling date (9 September 2004), a rain event, two areas of Fish Creek stood out in terms of high total suspended solids (TSS) concentrations. Site 1 on Scott Road had the highest TSS concentration found in the entire study (382.0 mg/L) and site 17 at 183.0 mg/L had elevated levels of TSS (Figure 5). As expected on the non-event sampling date, 14 September 2004, all sites sampled were low in TSS (maximum concentration was 6.7 mg/L). On 8 December 2004 and 4 January 2005, sites 1 and 17 were once again identified as having sources of total suspended solids in their reaches of Fish Creek. For example, on 8 December 2004, site 17 (Wheeler Road) had the highest TSS concentration found on that date (15.7 mg/L, Figure 11) and TSS increased from 10.0 mg/L at site 3 (Culvert Road) downstream to 11.7 mg/L at site 1 (Scott Road) (Figure 11). Similarly on 4 January 2005, TSS increased from site 3 (8.5 mg/L) downstream to site 1 (10.2 mg/L) and site 17 (Wheeler Road) had the next highest TSS concentration found in the watershed at 5.2 mg/L (Figure 14). Additional sites were added to further pinpoint these sources and some of the subsequent sampling identified other intermittent sources of total suspended solids in the Fish Creek watershed.

1. **Site 3 on Culvert Road downstream to site 2 on Portage Road and the reach between site 2 and site 1 on Scott Road:** The addition of site 2 on Portage Road on 15 February and 4 April 2005 demonstrated that the majority of suspended solids were added to the creek between site 3 on Culvert Road downstream to site 2 on Portage Road. For example, on 15 February 2005, TSS increased from 16.0 mg/L at site 3 to 71.0 mg/L at site 2 (Figure 17) and TSS increased from 30.5 mg/L at site 3 to 59.0 mg/L at site 2 on 4 April 2005 (Figure 20). Additional suspended solids were washed from the watershed in the reach of Fish Creek between site 2 on Portage Road (59.0 mg/L) and site 1 on Scott Road (81.0 mg/L) on 4 April 2005 suggesting an additional source in this reach (Figure 20). The land use between site 3 on Culvert Road and site 1 on Scott Road is a mix of cropland and orchard with a wooded buffer along the stream. The creek banks are very steep in this area and there is an area upstream from site 2 where there is little cover on the banks making them prone to erosion. **See Illustration 1, page 22.**
2. **Site 17 on Wheeler Road upstream to Townline Road and upstream of site 17N on Townline Road.** On 15 February 2005, the reach of Fish Creek sampled at site 17N (Townline Road) contributed the highest concentration of TSS (18.5 mg/L at site 17N versus 2.5 mg/L at site 17S and 1.3 mg/L at site 17) (Figure 17) suggesting a source in this area. On 4 April 2005, a source of TSS was identified between the two sites (17N [19.5 mg/L] and 17S [15.5 mg/L]) on Townline Road downstream to site 17 (42.0 mg/L) on Wheeler Road (Figure 20). The final sampling date (31 August 2005) did not yield any additional evidence as to sources of total suspended solids in the site 17 reach of Fish Creek as all TSS concentrations were similar (range = 2.0 to 3.5 mg/L) (Figure 23). The predominant land use in this area is agriculture.

3. **Upstream of site 8 on Long Bridge Road on 15 February 2005 and upstream of site 9 on County House Road on 31 August 2005:** Two intermittent sources of total suspended solids to Fish Creek were identified on one of the sampling dates. Site 8 (Long Bridge Road) had the third highest concentration on 15 February 2005 at 23.5 mg/L (Figure 17) and site 9 on County House Road had the highest TSS concentration found on 31 August 2005 (57.0 mg/L, Figure 23). Both areas have agricultural land use.

SUMMARY OF THE SOURCES IDENTIFIED (Figure 2)

As expected in this rural watershed, agriculture is the predominate source of elevated levels of nutrients, soil and salt to Fish Creek. During this year-long study, the locations and magnitude of the sources identified varied undoubtedly due to changing agricultural conditions and practices implemented throughout the study period. In general, most identified sources were in association with row crops such as cabbage, corn and soybeans

Another generalization is that the highest loss from watersheds were associated with the highest precipitation amounts. For example, on 9 September 2004, where over three inches of rain fell in the watershed, the highest TP concentrations were 805.9 μg P/L at site 1 (Scott Road), 599.3 μg P/L at site 17 (Wheeler Road) and 570.7 μg P/L at site 3 (Culvert Road). Similarly, three inches of rain fell before the sampling effort on 31 August 2005 and the highest total phosphorus concentration observed throughout the entire study was found at site 17NE (2169.3 µg P/L) (Figure 21). Site 17S on Townline Road also had a TP concentration of 733.3 µg P/L on that same day. This suggests soil and nutrients are being carried by surface water flow over fields.

Below is a list of each identified source in the Fish Creek watershed with summary of the parameter(s) identified and the land use in the identified area:

1. There are multiple sources of total phosphorus, total Kjeldahl nitrogen, and total suspended solids between site 3 on Culvert Road downstream to site 1 on Scott Road. The sources in this reach are associated with soil loss from the watershed and are most evident during the highest runoff events. Although there is a wooded buffer adjacent to the stream, the banks of the stream are steep in this area with areas of sparse vegetation, especially upstream of site 2, making portions of the stream bank prone to erosion. See Illustration 1, page 22.

2. There is a source of total phosphorus, soluble reactive phosphorus, nitrate, total Kjeldahl nitrogen, total suspended solids and sodium upstream of site 8 on Long Bridge Road. The land use in this reach of Fish Creek is cropland for a dairy farm and a vegetable farm with some residential and wooded areas. See Illustration 1, page 22.

3. There is a source of nitrate, total Kjeldahl nitrogen, total suspended solids and sodium upstream of site 9 on County House Road. The land use in this reach of Fish Creek is cropland currently in soybeans, corn and cabbage. See Illustration 1, page 22.

4. A source of erosion is evident in the area from Townline Road (sites 17N and 17S) downstream to site 17 on Wheeler Road. Total suspended solids more than doubled from the upstream sites (17N – 19.5 mg/L and 17S – 15.5 mg/L) downstream to site 17 where the suspended solids concentration had increased to 42.0 mg/L on 4 April 2005. There is agricultural land use in this area.

5. The highest phosphorus concentrations (both TP and SRP) recorded during this study were found at site 17NE south of Pask Road on 31 August 2005. This headwater site is characterized by cropland, orchards and woods. Summer agricultural practices should be reviewed in this area. See Illustration 1, page 22.

6. A source of both soluble and total phosphorus was found in the agricultural area upstream of site 17S on Townline Road.

7. The reach of Fish Creek upstream of site 18 on Route 31A was a source of nitrogen (both nitrate and total Kjeldahl nitrogen) and sodium to the creek. The land use in this reach is agriculture mixed with woodlands.

8. There is a source of TKN and nitrate upstream of site 11 on Route 31A where agricultural row crops is the predominate land use that also includes some woodlots.

9. There is a source of sodium from roadside drainage at site 3A adjacent to Culvert Road and site 11A adjacent to Route 31A. Site 11A was also a source of TKN on 31 August 2005.

10. There is a source of soluble reactive phosphorus in the headwater reach of Fish Creek characterized by sites 14 (Martin Road) and site 15 (Bigford Road). There was also a source of total Kjeldahl nitrogen upstream of Bigford Road. The land use in these areas is predominately agricultural row crops mixed with woodlands. There is a large wooded buffer around Fish Creek in the area upstream of site 15 that slows and absorbs runoff from the agricultural land that surrounds it. The buffer is not keeping out all the agricultural runoff from making it to the stream especially during large runoff events.

DISCUSSION

The quality and quantity of runoff from a watershed into a stream are ultimately influenced by the land use and interactions with inhabitants of the watershed. The amount of runoff is determined by the amount of excess precipitation, that which neither sinks into the ground nor is stored at the surface. Precipitation excess is determined primarily by climate, vegetation, infiltration capacity, surface storage and land use by people. Impervious landscapes (e.g., parking lots), removal of wetlands and vegetation in general, storm sewers, blockage of streams by debris, etc., all contribute to rapid rises in stream level and potential flooding. Surface runoff dissolves constituents such as the soluble forms of nutrients (phosphate and nitrate) and salts (sodium) from the soil and other surfaces it contacts carrying them to the stream. Runoff also scours and erodes the surfaces it flows over sweeping soil particles containing phosphorus and nitrogen from the watershed into the stream. Land use and surface conditions determine, to a large degree, the magnitude of the loss of these constituents from the watershed to the stream via these processes. For example, a tilled agricultural field that is subjected to surface runoff from precipitation or snow melt will lose a large amount of soil and nutrients to the stream as that water flows over the exposed surfaces. Land use and agricultural practices initiated by people can and do affect stream water quality and stream discharge. If we can identify the sources of pollution, remedial action plans and best management plans can be initiated that mitigate downstream and lake effects.

Best Management Practices:
Identified point and non-point sources of nutrients and solids can be remediated using Best Management Practices (BMP). Whether or not management practices include a reduction of cropland or fertilization, control of water movement can be a means of significantly reducing non-point source pollution. Since water must come in contact with the nutrient source and then be transported to the surface (or subsurface) water body, the nutrients in water bodies are functions of soil fertility and quantities of transporting water.

Water Management: Management practices, which reduce surface runoff, have been shown to dramatically decrease the magnitudes of sediment and chemical losses from land areas (15). At Conesus Lake, construction of retention ponds/gully plugs successfully reduced the loss of soil by a factor greater than 90% in the first year (Appendix A, page 49). Construction of buffer strips, contour planting, timing of tilling practices and sediment retention ponds are methods successively shown to reduce overland flow of water from affected watersheds.

Agriculture: Haith (15) and the NYSDEC (16, 17) recommend use of buffer strips of forest or grass between the pollutant source and a stream to intercept the runoff, resulting in removal by deposition or filtering by the vegetative cover. Other cropland management practices include diversions, terraces contour cropping, strip cropping, waterways, minimum and no tillage. Site 8 and 17NE (Illustration 1, page 22) is a site where large amounts of nutrients and soil were being lost through the stream. From the illustration, it is clear that a larger buffer strip with live vegetation is required to reduce losses of valuable soil and nutrients to the creek. Similarly, erosion of the stream bank at Site 2 on Portage Road is obvious. Rip-rapping along this section would prove to reduce soil loss and associated nutrients. Similar situations exist at other sites.

Livestock operation controls include barnyard runoff management, manure storage facilities and livestock exclusion from woodlands. They may also include structural devices such as grassed waterways, sediment retention basins, erosion control weirs and animal waste holding tanks. BMP's are designed to reduce sediment and nutrient transport to streams and lakes. They may benefit the farmer in the long term by decreasing fuel and fertilizer costs and by improving soil productivity. Furthermore, with the advent of Concentrated Animal and Feed Operations (CAFO) permits, regulatory control of farms with large numbers of animals may be inevitable. Introduction of total farm planning practices may serve the farming community well.

Besides soil loss, much of the loss of nutrients in the Fish Creek watershed was in the dissolved form as nitrate and phosphorus. Information on nutrient management in agriculture settings in New York State is reviewed in a recent issue of Northeast Dairy Business and is applicable to other crops. For example, articles titled “Nine Tips to Manage N Better” (19) and “How Much P is Enough” (20) provide a useful review of nutrient management issues that are applicable to the Fish Creek watershed. Farmers in western New York have reduced fertilizer usage and successfully maintained corn yields while saving money.

Also, adoption of total farm planning practices has proven to be very successful and to serve several purposes on farms in the Conesus Lake area. These include:

1. Maintaining soil fertility by leaving more nutrients and soil on agricultural land;
2. Reducing the amount of soil and nutrients washed into Fish Creek, Oak Orchard Creek and eventually Lake Ontario. This reduces the overproduction (eutrophication) of downstream systems and the aesthetically unappealing blooms of algae and weeds (Appendix A, page 49); and,
3. Potentially an increase in economic return to the farmer. Recent work on dairy farms in Conesus Lake have demonstrated that a reduction in nitrate fertilization rates actually maintained corn yields, reduced nitrate lost to downstream systems while allowing a savings in money to the farmer. Soil testing documented that levels of soil phosphorus were more than adequate for maintaining yields (18).

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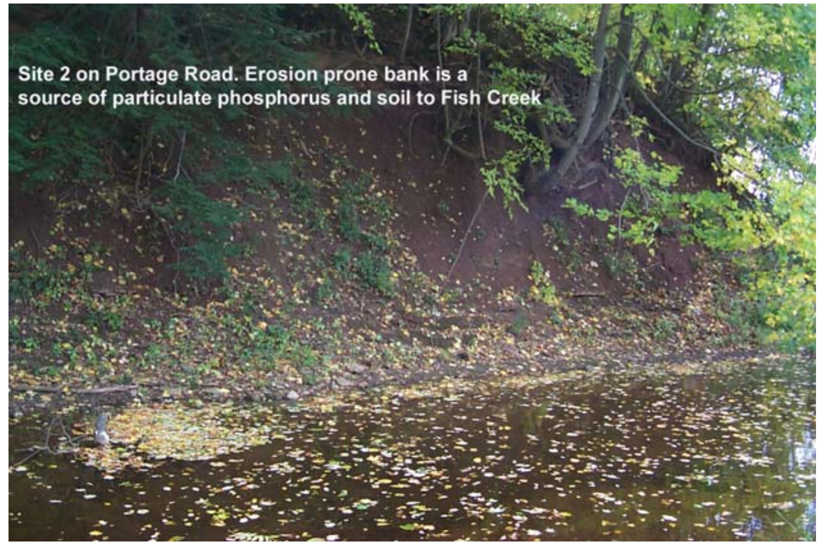


Illustration 1. Annotated photographs of sources of nutrients, soil and sodium to the Fish Creek. TP = total phosphorus, SRP = soluble reactive phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen.

Table 1. Location of Fish Creek sampling locations. Both the nearest road location and the latitude and longitude measured by GPS are presented.

Site #	Location	Latitude	Longitude
1	Scott Road	78.35903	43.25889
2	Portage Road	78.35278	43.24505
3	Culvert Road	78.34051	43.23721
3A	Drainage Pipe adjacent to Culvert Road	78.34055	43.23707
7	Wood Road	78.29893	43.22444
8	Long Bridge Road	78.28427	43.22289
9	County House Road	78.29041	43.21307
10	Dresser Road	78.32495	43.20967
11	Route 31A	78.32978	43.20782
11A	Roadside ditch along Route 31A	78.33010	43.20780
12	Route 31A	78.32805	43.18587
14	Martin Road	78.34376	43.18587
15	Bigford Road	78.34910	43.17023
17	Wheeler Road	78.31330	43.18580
17 N	Town Line Road South	78.31030	43.18350
17NE	South of Pask Road	78.28848	43.17757
17 S	Town Line Road North	78.31020	43.18130
18	West Lee Road	78.31269	43.20348

Table 2. Precipitation amounts for a 24-hour period on the date of sampling and for the previous day. Precipitation data for 9 September 2004 to 4 April 2005 taken from the NCDC website for the Albion 2 NE Weather Station. Precipitation data for 31 August is preliminary local climatological data for Buffalo, NY taken from the National Weather Service Forecast Office Website.

Date	Daily Precipitation (Inches)	Previous Day Precipitation (Inches)
9 September 2004	3.28	0.18
14 September 2004	0.00	0.00
8 December 2004	0.20	0.34
4 January 2005	0.12	0.12
15 February 2005	0.11	0.29
4 April 2005	0.37	1.32
31 August 2005	1.98	1.02

Table 3 – ELAP January 2005 Results

WADSWORTH CENTER

NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

Proficiency Test Report

Lab 11439 | SUNY BROCKPORT | EPA Lab Id | NY01449 | Page 1 of 1

WATER LAB LENNON HALL
BROCKPORT, NY 14420
USA

Shipment 240 Non Potable Water Chemistry
Shipment Date: 24-Jan-2005

Analyte	Sample ID	Result	Mean/Target	Satisfactory Limits	Method	Score
Approval Category : **Non Potable Water**						
Sample: **Residue**						
Solids, Total Suspended 0 passed out of 264 reported results. Results were thrown out for all labs.	8002	40.4	42.8		SM18-20 2540D	Not Scored
Sample: **Organic Nutrients**						
Kjeldahl Nitrogen, Total 95 passed out of 102 reported results.	8004	3.30	3.89	2.56 – 5.22	EPA 351.2	Satisfactory
Phosphorus, Total 111 passed out of 124 reported results.	8004	6.84	7.09	5.39 – 8.29	SM18-20 4500-PF	Satisfactory
Sample: **Inorganic Nutrients**						
Nitrate (as N) 109 passed out of 114 reported results.	8007	12.70	13.5	10.7 – 16.0	SM18-20 4500-NO3 F	Satisfactory
Orthophosphate (as P) 96 passed out of 101 reported results.	8007	4.29	4.42	3.78 – 5.10	SM18-20 4500-PF	Satisfactory
Sample: **Minerals II**						
Sodium, Total 78 passed out of 93 reported results.	8037	79.14	77.5	70.0 – 84.9	SM 18-19 3111B	Satisfactory

Table 4. Water chemistry results for Fish Creek from September 2004 to August 2005. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP= soluble reactive phosphorus.

Sample	Date Collected	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Fish Creek SSA - Orleans Site 1	9/9/2004	805.6	1.64	382.0	1860	3.90	233.1
Fish Creek SSA - Orleans Site 3	9/9/2004	570.7	1.66	143.5	1580	3.20	263.7
Fish Creek SSA - Orleans Site 7	9/9/2004	495.6	1.74	87.5	1520	3.40	262.0
Fish Creek SSA - Orleans Site 10	9/9/2004	375.5	1.01	102.5	1140	2.46	141.2
Fish Creek SSA - Orleans Site 14	9/9/2004	334.6	0.57	77.5	930	0.50	160.7
Fish Creek SSA - Orleans Site 17	9/9/2004	599.3	0.67	183.0	1250	1.80	311.8
Fish Creek SSA - Orleans Site 18	9/9/2004	243.8	1.08	50.0	1040	2.49	95.7
Fish Creek SSA - Orleans Site 1	9/14/2004	71.3	4.91	4.2	730	15.09	29.6
Fish Creek SSA - Orleans Site 3	9/14/2004	65.8	6.82	5.0	580	14.76	61.3
Fish Creek SSA - Orleans Site 7	9/14/2004	53.8	19.42	5.3	610	30.67	42.2
Fish Creek SSA - Orleans Site 10	9/14/2004	65.6	7.07	4.8	510	12.40	50.5
Fish Creek SSA - Orleans Site 14	9/14/2004	132.7	0.84	6.7	840	3.99	90.9
Fish Creek SSA - Orleans Site 17	9/14/2004	187.3	0.59	4.0	710	6.29	170.8
Fish Creek SSA - Orleans Site 18	9/14/2004	39.6	5.94	3.3	330	24.07	32.2
Fish Creek SSA - Orleans Site 1	12/8/2004	119.9	3.64	11.7	460	16.09	46.9
Fish Creek SSA - Orleans Site 3	12/8/2004	122.3	4.10	10.0	1730	13.53	47.2
Fish Creek SSA - Orleans Site 7	12/8/2004	57.9	14.60	2.1	540	24.86	35.8
Fish Creek SSA - Orleans Site 10	12/8/2004	109.2	3.93	10.2	700	10.86	35.5
Fish Creek SSA - Orleans Site 14	12/8/2004	173.3	1.28	7.8	230	8.09	30.5
Fish Creek SSA - Orleans Site 17	12/8/2004	105.7	2.39	15.7	410	5.02	70.0
Fish Creek SSA - Orleans Site 18	12/8/2004	36.8	3.72	7.6	410	16.03	10.1
Fish Creek SSA - Orleans Site 1	1/4/2005	125.3	4.44	10.2	470	14.36	59.4
Fish Creek SSA - Orleans Site 3	1/4/2005	123.9	3.77	8.5	350	12.92	59.4
Fish Creek SSA - Orleans Site 7	1/4/2005	79.6	9.01	4.1	390	21.16	55.6
Fish Creek SSA - Orleans Site 10	1/4/2005	99.0	2.03	5.0	590	8.84	34.7
Fish Creek SSA - Orleans Site 14	1/4/2005	98.1	1.10	2.1	560	5.34	29.8
Fish Creek SSA - Orleans Site 17	1/4/2005	176.5	1.34	5.2	630	3.48	57.0
Fish Creek SSA - Orleans Site 18	1/4/2005	37.0	3.69	3.3	440	12.22	12.4

Table 4 (cont.). Water chemistry results for Fish Creek from September 2004 to August 2005. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and SRP= soluble reactive phosphorus.

Sample	Date	TP (µg P/L)	Nitrate (mg N/L)	TSS (mg/L)	TKN (µg N/L)	Sodium (mg/L)	SRP (µg P/L)
Fish Creek SSA - Orleans Site # 1	2/15/2005	175.5	2.19	33.0	1250	17.19	74.5
Fish Creek SSA - Orleans Site # 2	2/15/2005	218.3	2.48	71.0	1370	16.89	73.5
Fish Creek SSA - Orleans Site # 3	2/15/2005	152.9	2.12	16.0	1190	15.92	78.2
Fish Creek SSA - Orleans Site # 7	2/15/2005	151.2	2.98	19.0	830	20.75	78.5
Fish Creek SSA - Orleans Site # 8	2/15/2005	189.5	3.20	23.5	1080	15.10	123.4
Fish Creek SSA - Orleans Site # 9	2/15/2005	82.1	3.91	9.7	670	2.30	39.6
Fish Creek SSA - Orleans Site # 10	2/15/2005	128.0	1.70	22.5	970	11.06	56.1
Fish Creek SSA - Orleans Site # 14	2/15/2005	84.6	1.24	6.7	860	5.85	43.9
Fish Creek SSA - Orleans Site # 15	2/15/2005	95.1	1.35	<0.2	1030	8.16	60.9
Fish Creek SSA - Orleans Site # 17	2/15/2005	121.8	1.29	1.3	950	5.17	57.6
Fish Creek SSA - Orleans Site # 17N	2/15/2005	132.7	1.45	18.5	730	3.97	59.6
Fish Creek SSA - Orleans Site # 17S	2/15/2005	83.2	1.31	2.5	820	4.31	29.5
Fish Creek SSA - Orleans Site # 18	2/15/2005	66.3	2.13	6.5	670	18.24	20.2
Fish Creek SSA - Orleans Site # 1	4/4/2005	178.9	1.46	81.0	910	9.28	85.8
Fish Creek SSA - Orleans Site # 2	4/4/2005	135.0	1.48	59.0	820	8.44	82.7
Fish Creek SSA - Orleans Site # 3	4/4/2005	134.4	1.62	30.5	820	7.97	62.8
Fish Creek SSA - Orleans Site # 7	4/4/2005	113.1	2.89	14.0	620	13.18	72.1
Fish Creek SSA - Orleans Site # 8	4/4/2005	171.8	2.73	10.0	660	10.56	106.1
Fish Creek SSA - Orleans Site # 9	4/4/2005	68.6	4.35	9.4	1070	1.32	28.1
Fish Creek SSA - Orleans Site # 10	4/4/2005	110.6	1.49	29.0	1110	4.95	45.8
Fish Creek SSA - Orleans Site # 14	4/4/2005	101.0	0.73	17.0	730	4.54	32.3
Fish Creek SSA - Orleans Site # 15	4/4/2005	104.6	0.66	12.0	700	4.03	39.6
Fish Creek SSA - Orleans Site # 17	4/4/2005	208.6	0.44	42.0	730	2.19	48.6
Fish Creek SSA - Orleans Site # 17N	4/4/2005	135.5	0.55	19.5	860	2.00	59.4
Fish Creek SSA - Orleans Site # 17S	4/4/2005	120.5	0.27	15.5	680	2.19	26.7
Fish Creek SSA - Orleans Site # 18	4/4/2005	89.5	4.19	28.7	730	10.57	35.2
Fish Creek SSA - Orleans Site 1	8/31/2005	68.8	0.47	17.0	280	16.01	36.9
Fish Creek SSA - Orleans Site 2	8/31/2005	143.7	0.74	31.5	530	37.17	72.5
Fish Creek SSA - Orleans Site 3	8/31/2005	565.3	7.43	42.0	1810	36.62	454.8
Fish Creek SSA - Orleans Site 3A	8/31/2005	179.5	0.56	6.0	880	94.40	120.5
Fish Creek SSA - Orleans Site 7	8/31/2005	374.1	3.22	3.5	1190	121.12	326.4
Fish Creek SSA - Orleans Site 8	8/31/2005	197.4	44.12	15.0	1720	30.11	125.6
Fish Creek SSA - Orleans Site 9	8/31/2005	244.0	1.87	57.0	1170	111.46	135.2
Fish Creek SSA - Orleans Site 10	8/31/2005	201.0	9.19	16.3	1030	36.84	120.0
Fish Creek SSA - Orleans Site 11	8/31/2005	177.1	13.90	22.8	1120	8.19	86.1
Fish Creek SSA - Orleans Site 11A	8/31/2005	185.5	9.88	5.3	1200	82.74	103.7
Fish Creek SSA - Orleans Site 12	8/31/2005	186.1	10.23	6.3	980	9.12	108.3
Fish Creek SSA - Orleans Site 14	8/31/2005	306.5	5.82	18.5	1130	3.54	216.9
Fish Creek SSA - Orleans Site 15	8/31/2005	251.2	5.19	3.8	1720	71.74	156.5
Fish Creek SSA - Orleans Site 17	8/31/2005	160.4	4.89	2.8	120	12.40	130.1
Fish Creek SSA - Orleans Site 17N	8/31/2005	244.0	3.96	3.5	650	5.73	191.5
Fish Creek SSA - Orleans Site 17 NE	8/31/2005	2169.3	0.14	2.7	700	1.66	788.0
Fish Creek SSA - Orleans Site 17 S	8/31/2005	733.3	1.63	2.0	920	19.42	220.3
Fish Creek SSA - Orleans Site 18	8/31/2005	286.1	11.30	6.0	1290	49.10	171.3

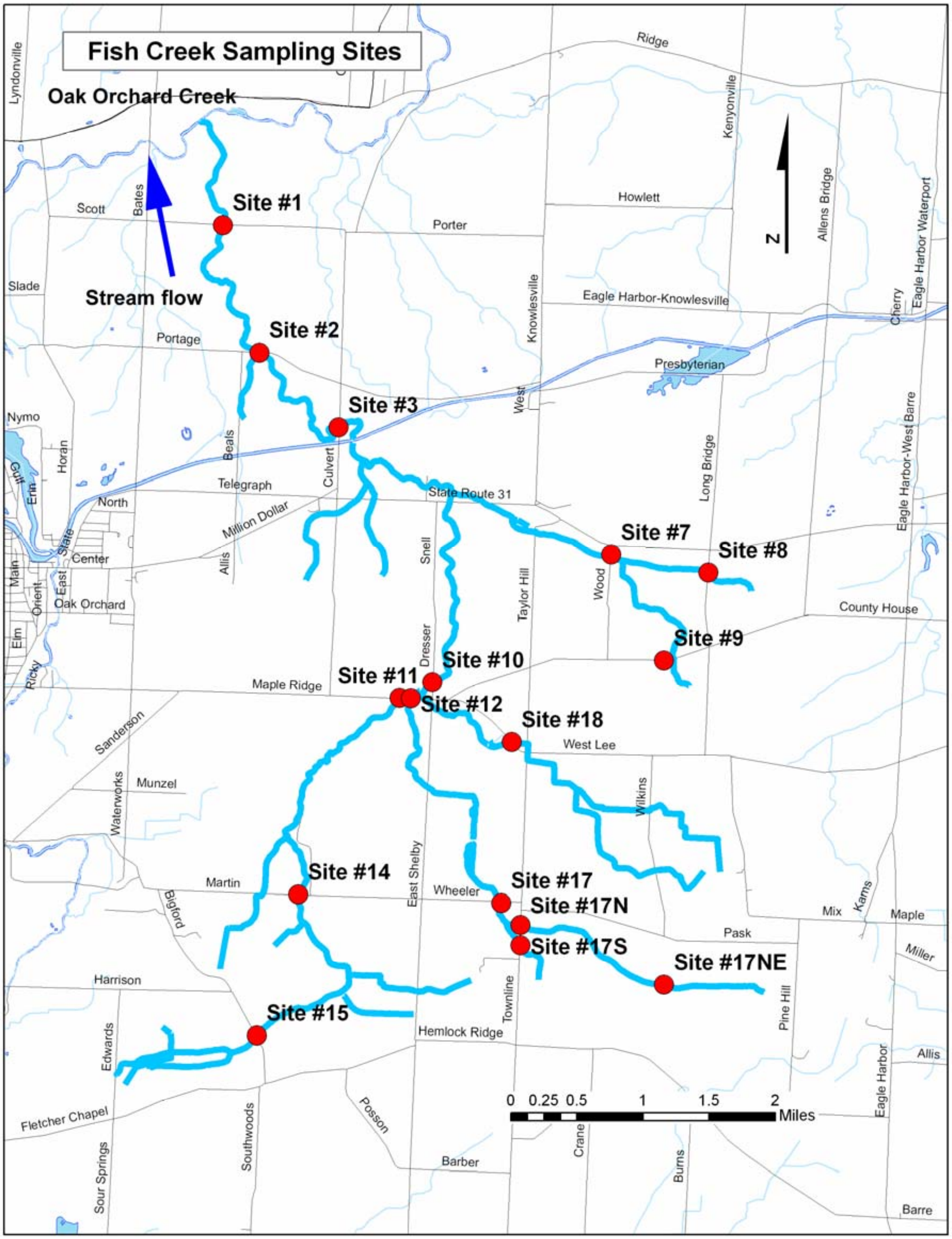


Figure 1. Locations of sampling sites on Fish Creek, Orleans County, NY. Sites 3A and 11A are drainage culverts that empty into the creek at sites 3 and 11, respectively.

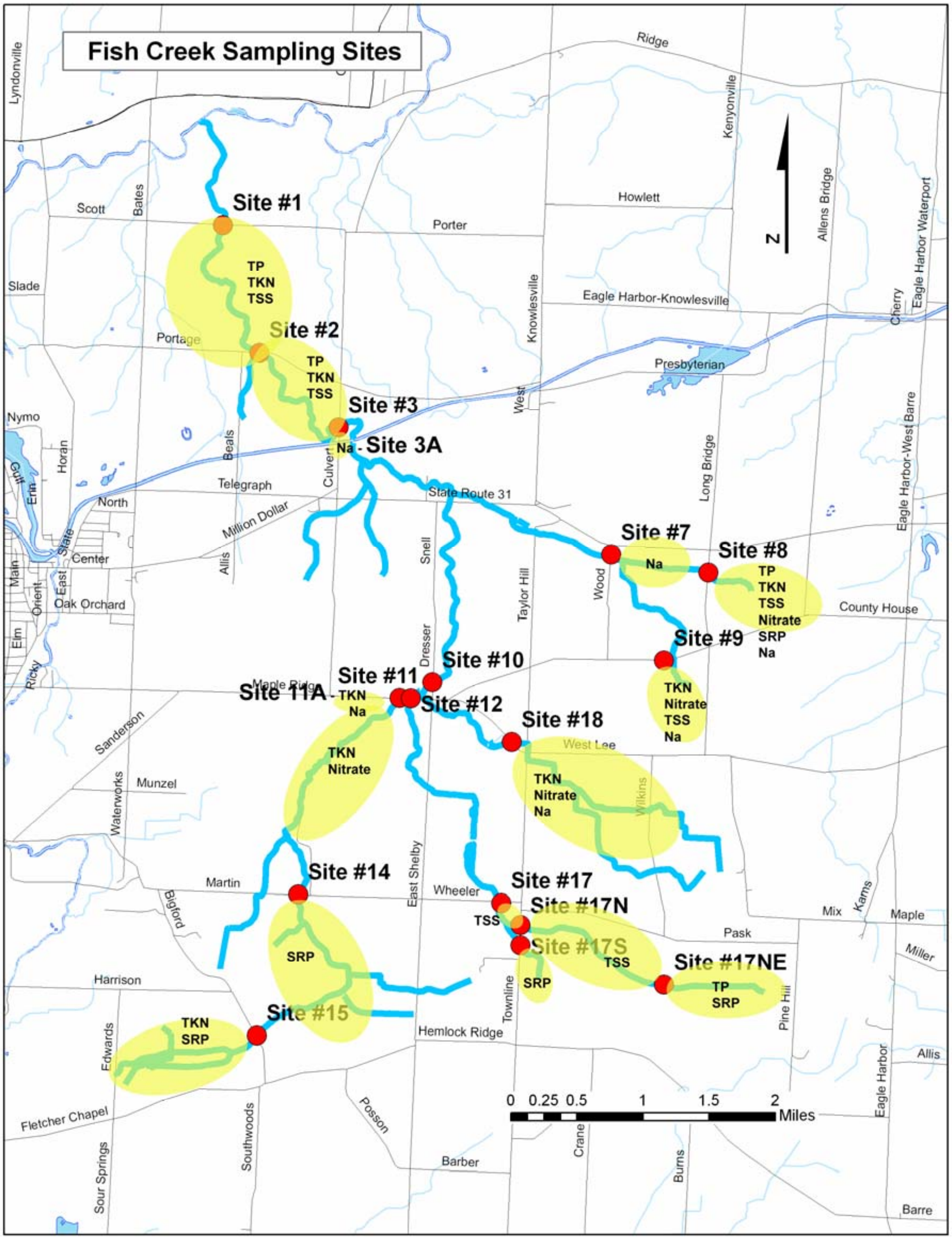


Figure 2. Areas of the Fish Creek watershed that have been identified as sources (depicted by the yellow bubbles) of nutrients and soil. The bubbles are labeled with the pollutant identified. Sites 3A and 11A are drainage culverts that empty into the creek at sites 3 and 11, respectively. TP = total phosphorus, SRP = soluble reactive phosphorus, TKN = total Kjeldahl nitrogen, TSS = total suspended solids and Na = sodium.

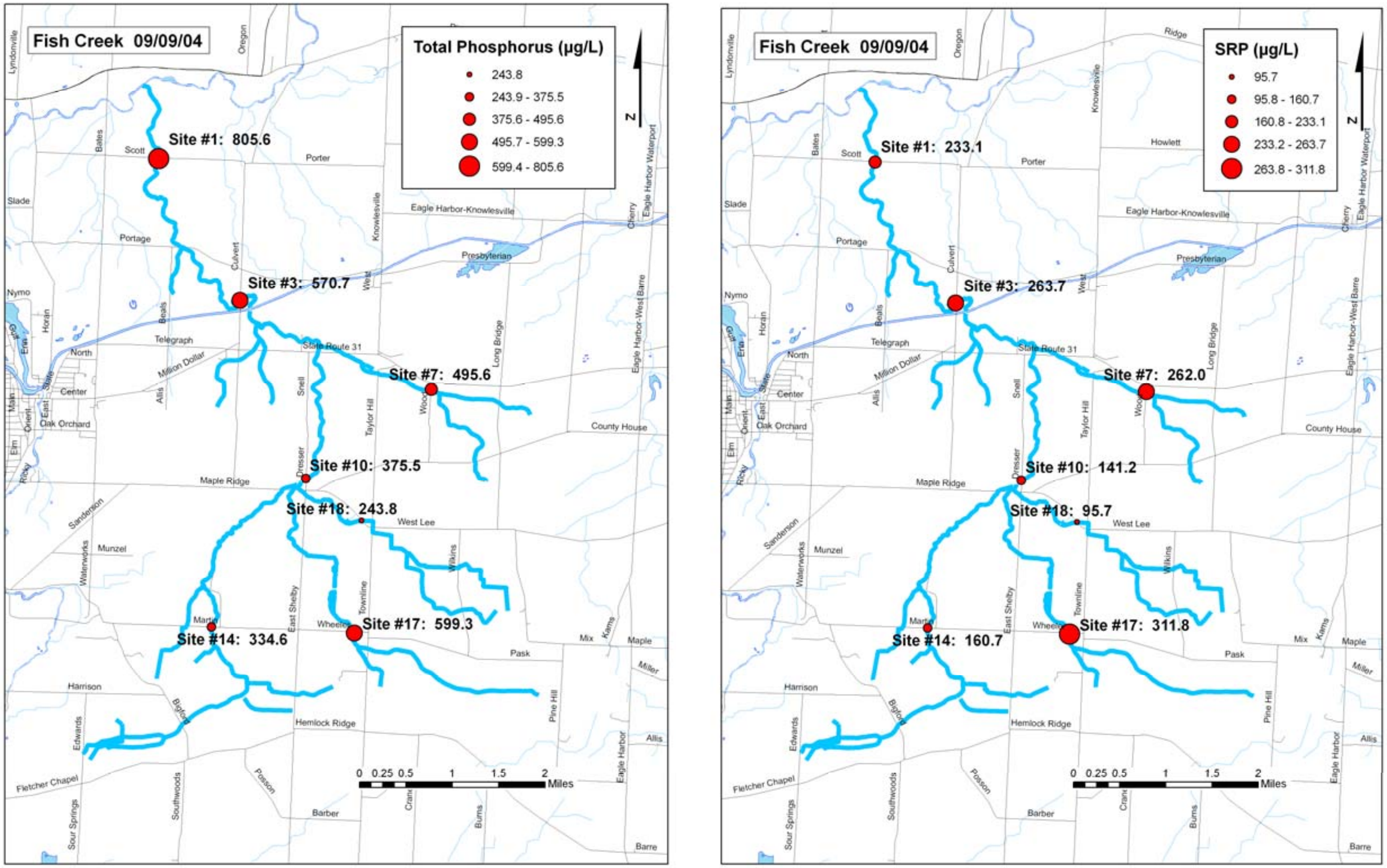


Figure 3. Total phosphorus and soluble reactive phosphorus for Fish Creek on 9 September 2004. The concentration of each parameter is presented next to each site number.

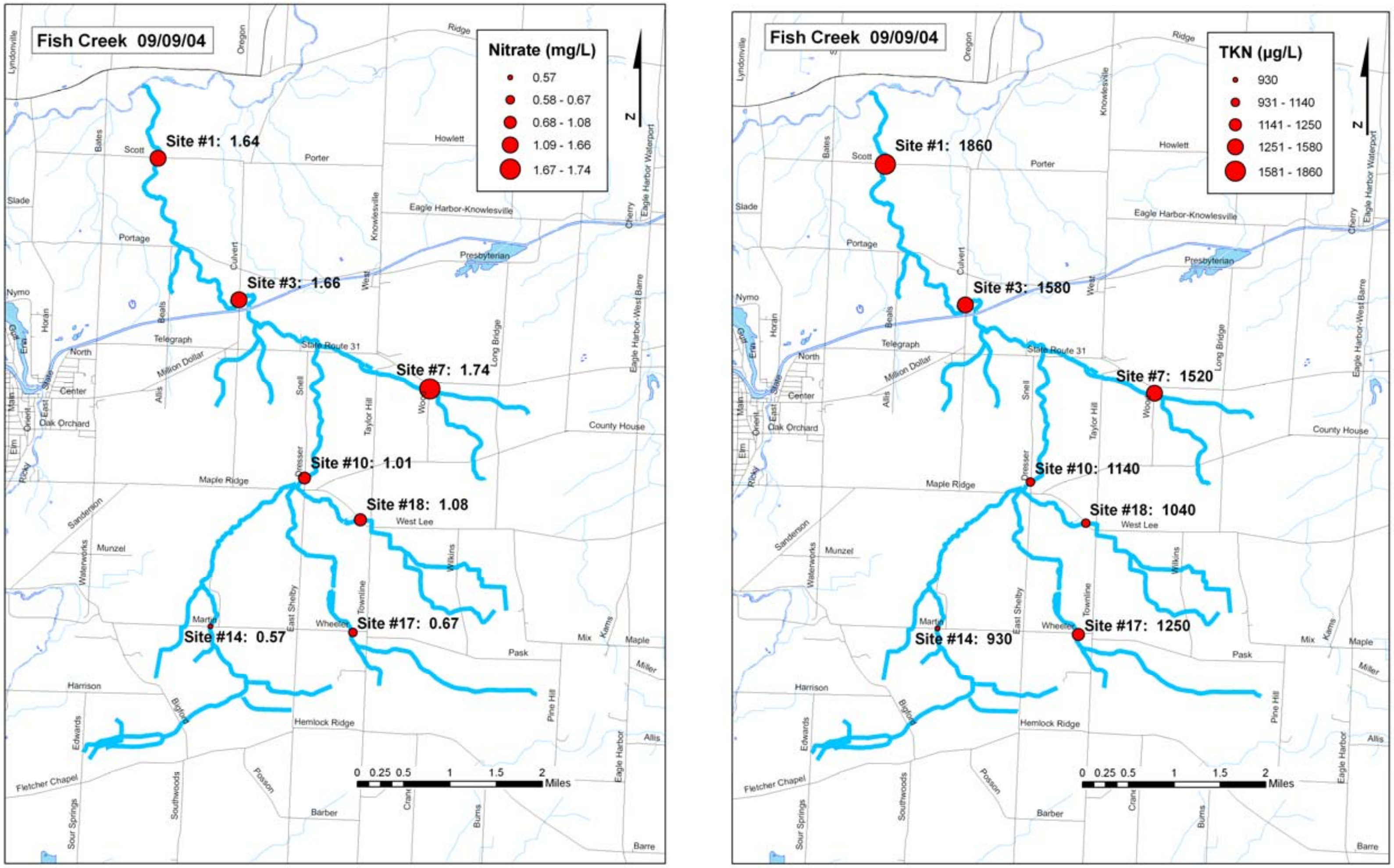
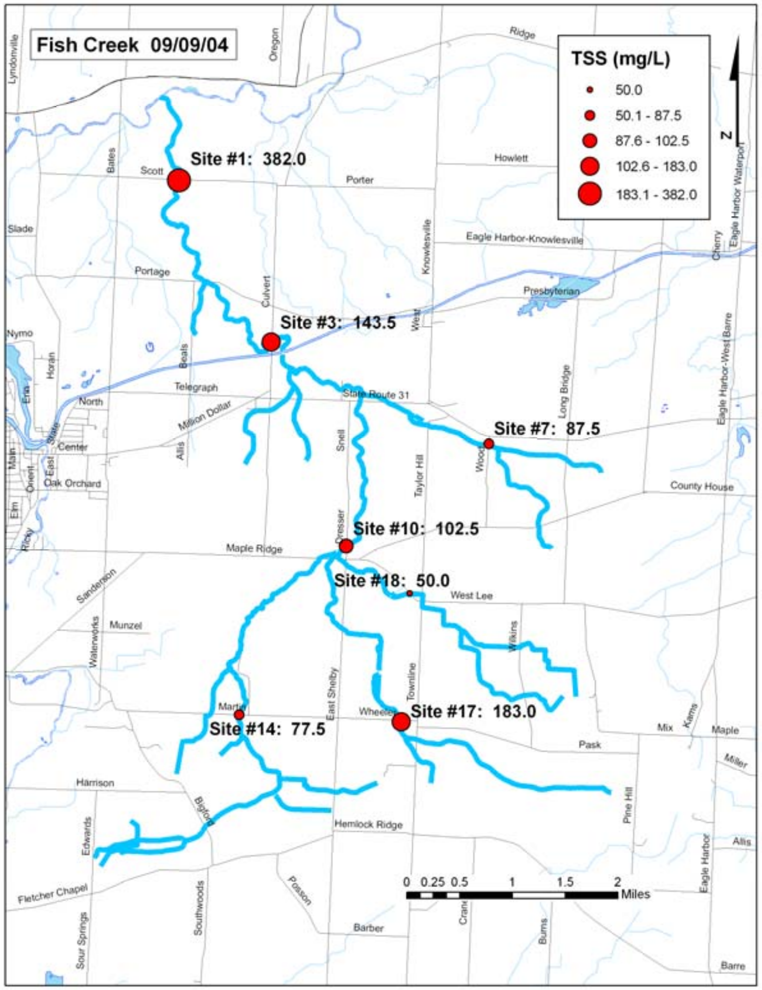


Figure 4. Nitrate and total Kjeldahl nitrogen for Fish Creek on 9 September 2004. The concentration of each parameter is presented next to each site number.



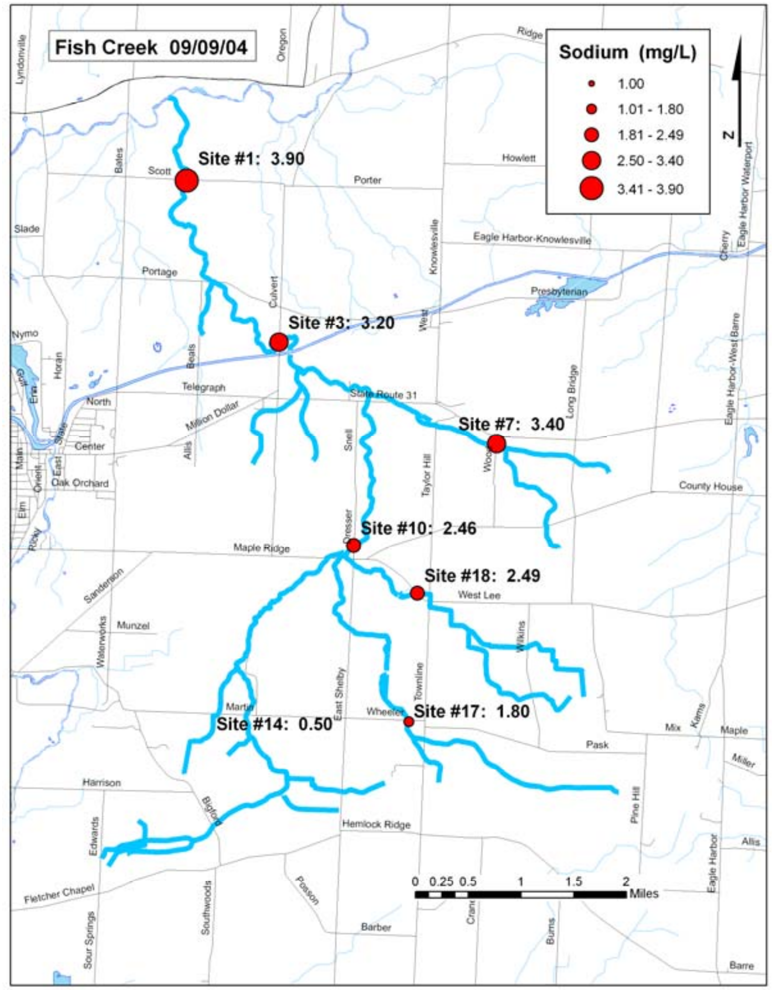


Figure 5. Total suspended solids and sodium for Fish Creek on 9 September 2004. The concentration of each parameter is presented next to each site number.

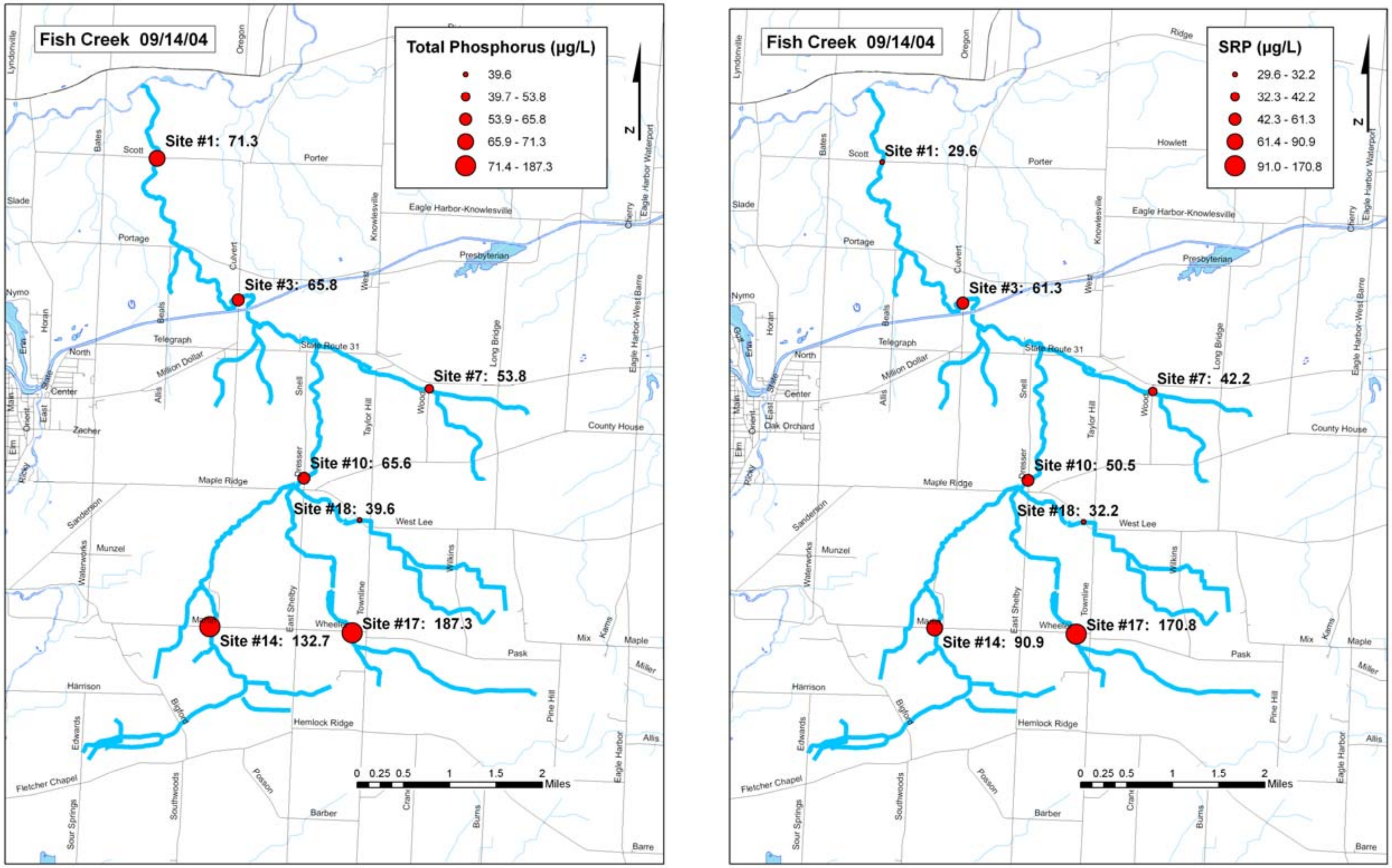


Figure 6. Total phosphorus and soluble reactive phosphorus for Fish Creek on 14 September 2004. The concentration of each parameter is presented next to each site number.

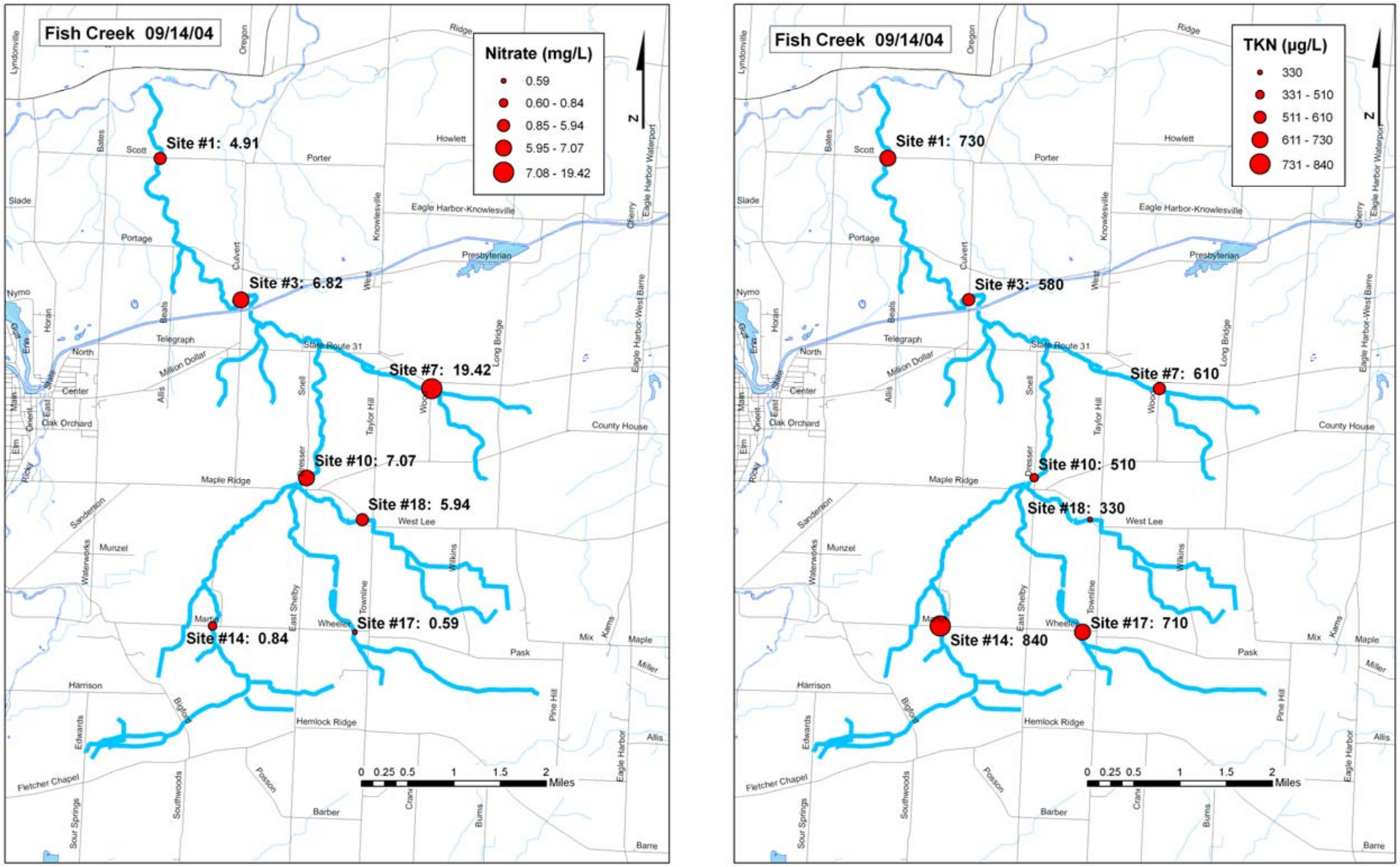


Figure 7. Nitrate and total Kjeldahl nitrogen for Fish Creek on 14 September 2004. The concentration of each parameter is presented next to each site number.

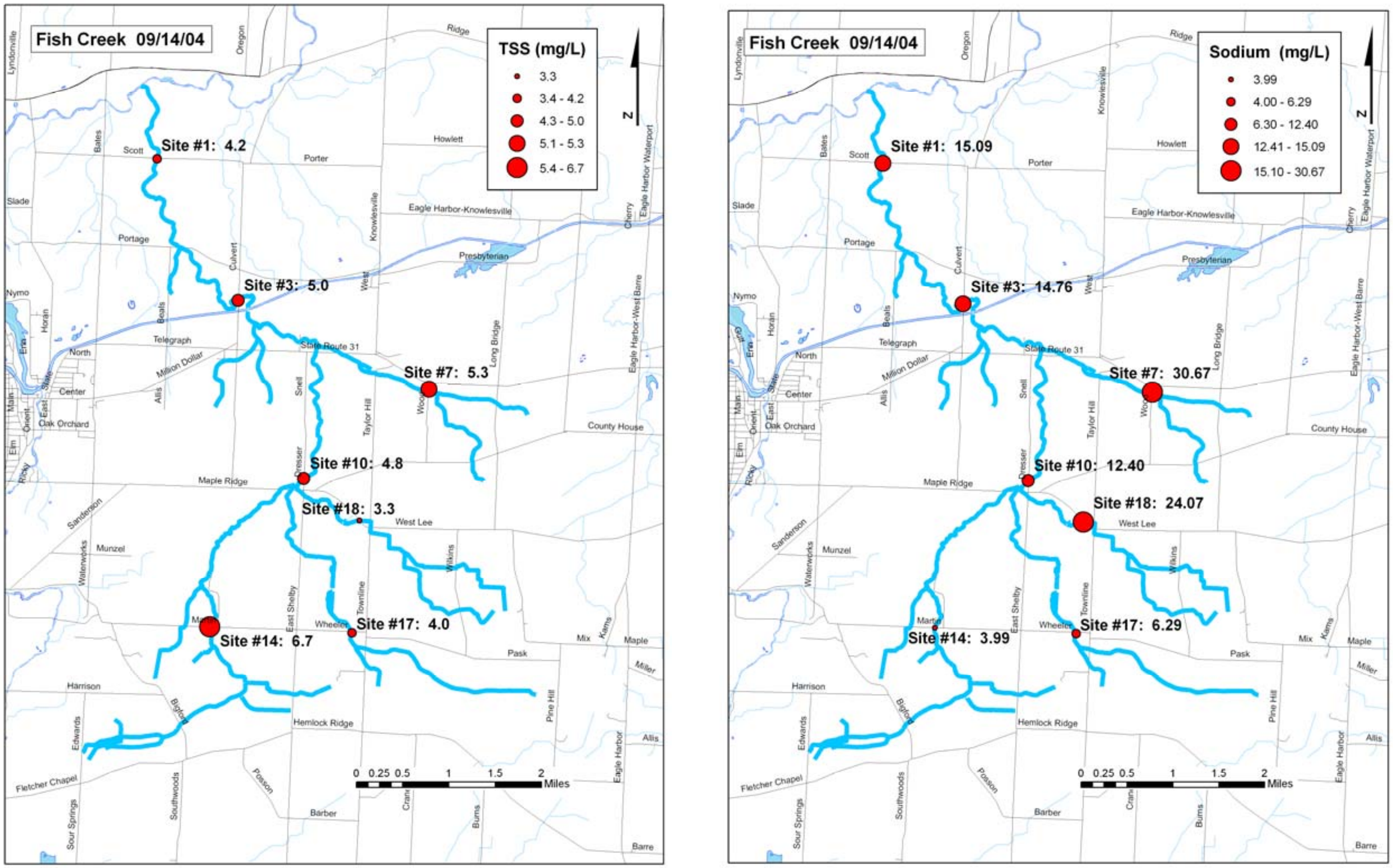
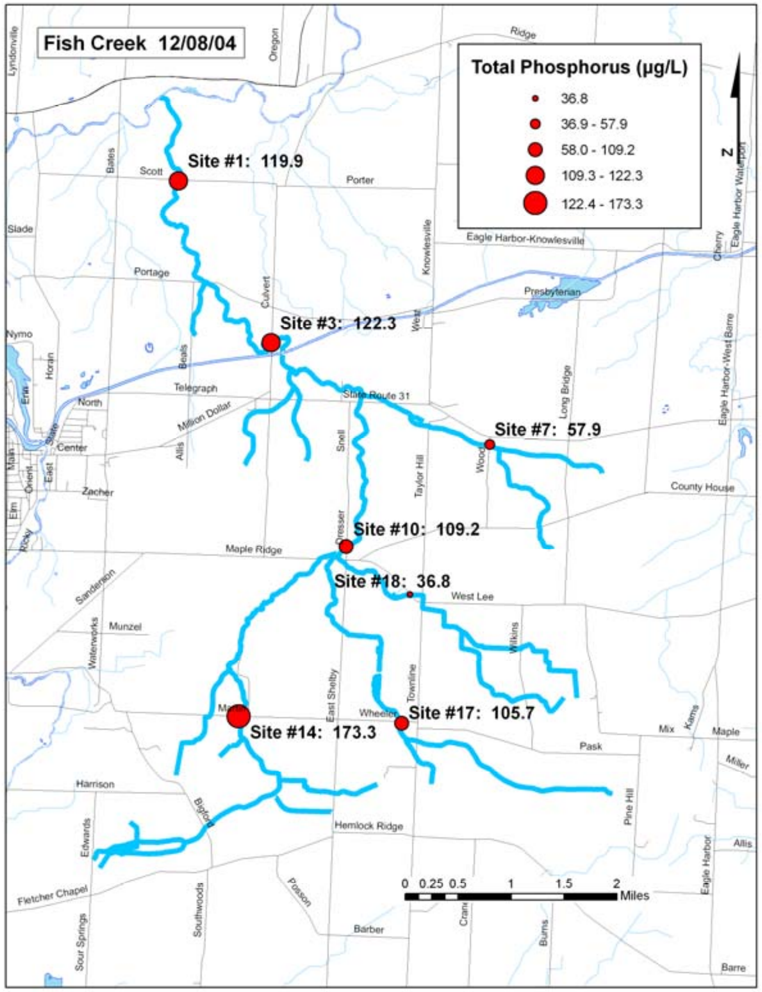


Figure 8. Total suspended solids and sodium for Fish Creek on 14 September 2004. The concentration of each parameter is presented next to each site number.



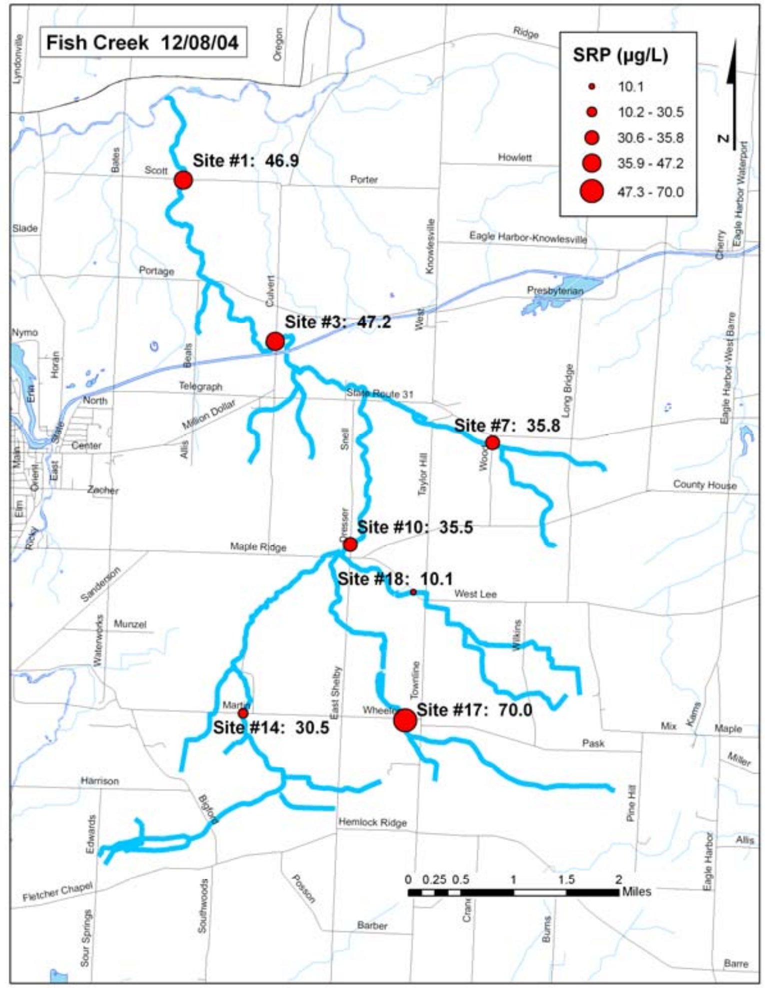
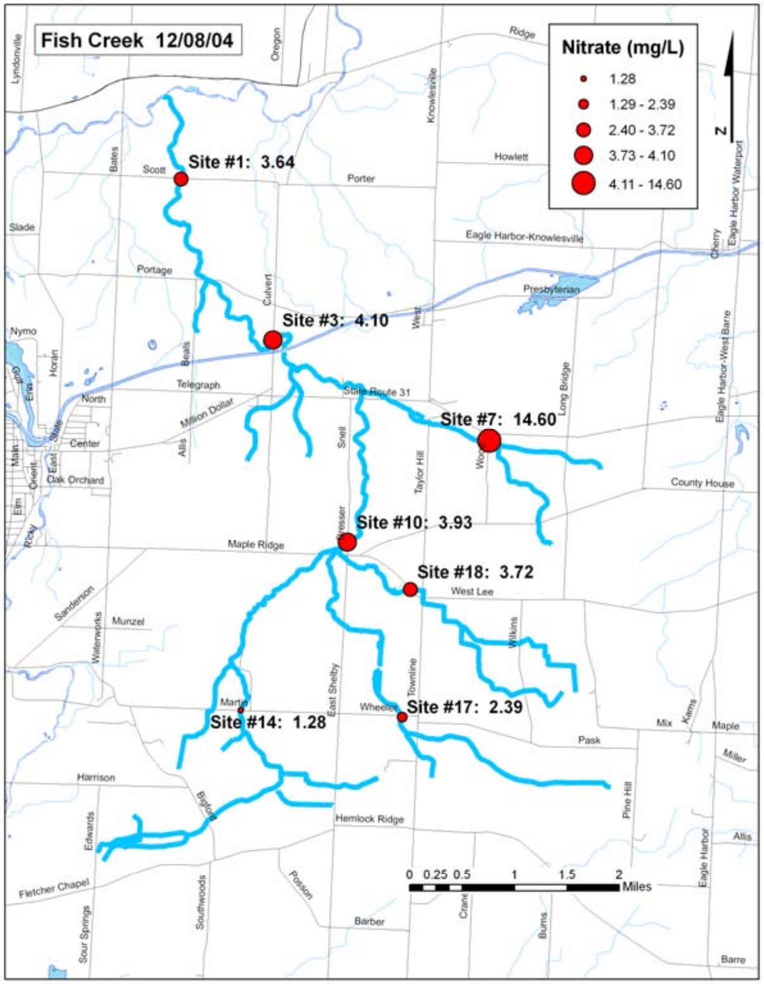


Figure 9. Total phosphorus and soluble reactive phosphorus for Fish Creek on 8 December 2004. The concentration of each parameter is presented next to each site number.



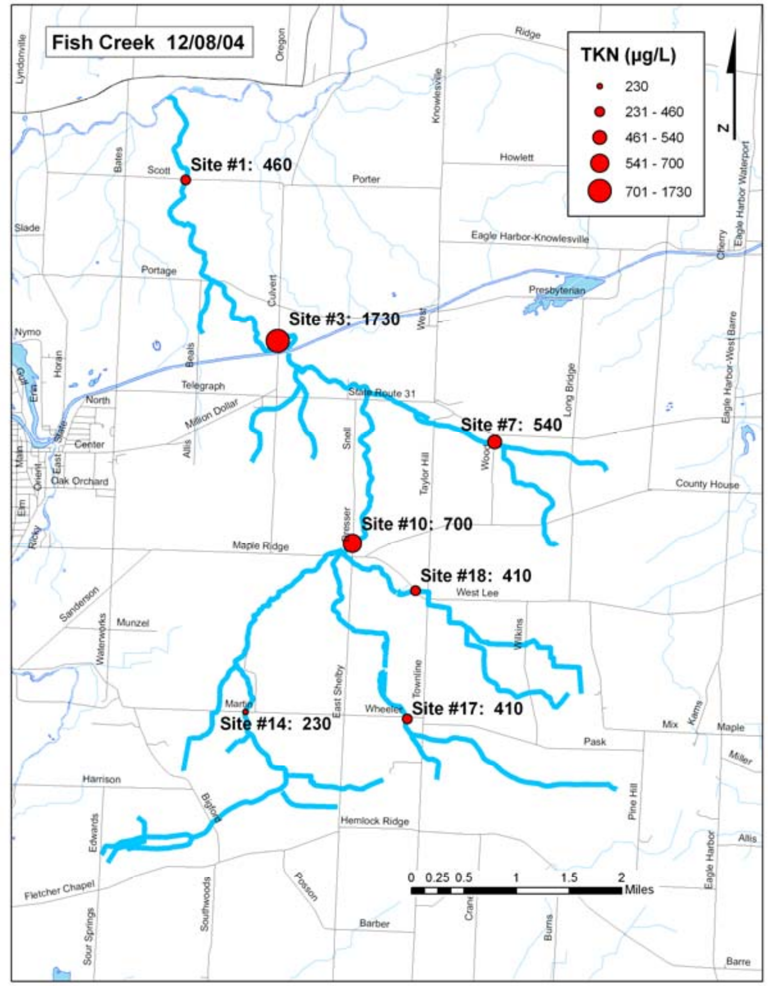


Figure 10. Nitrate and total Kjeldahl nitrogen for Fish Creek on 8 December 2004. The concentration of each parameter is presented next to each site number.

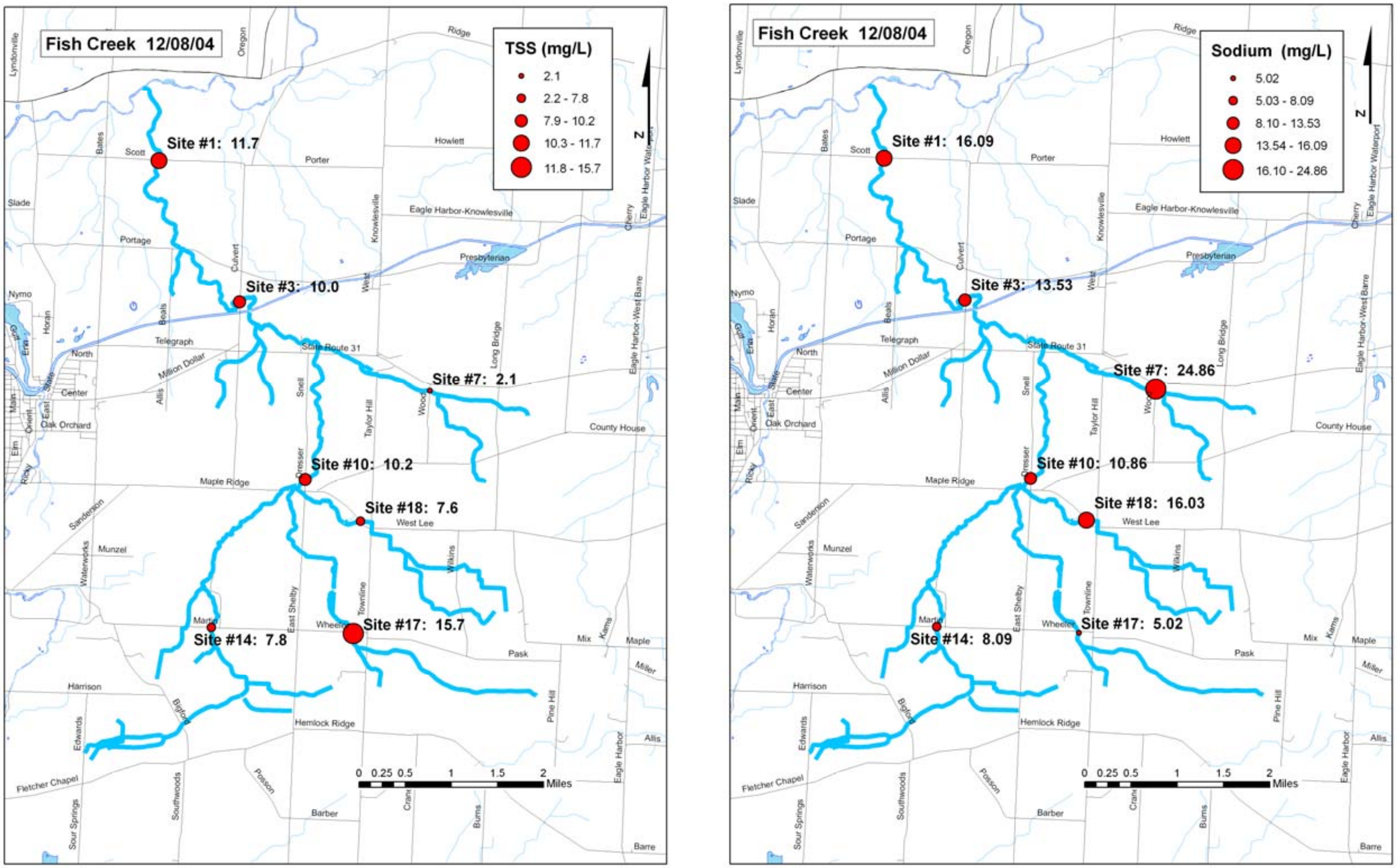


Figure 11. Total suspended solids and sodium for Fish Creek on 8 December 2004. The concentration of each parameter is presented next to each site number.

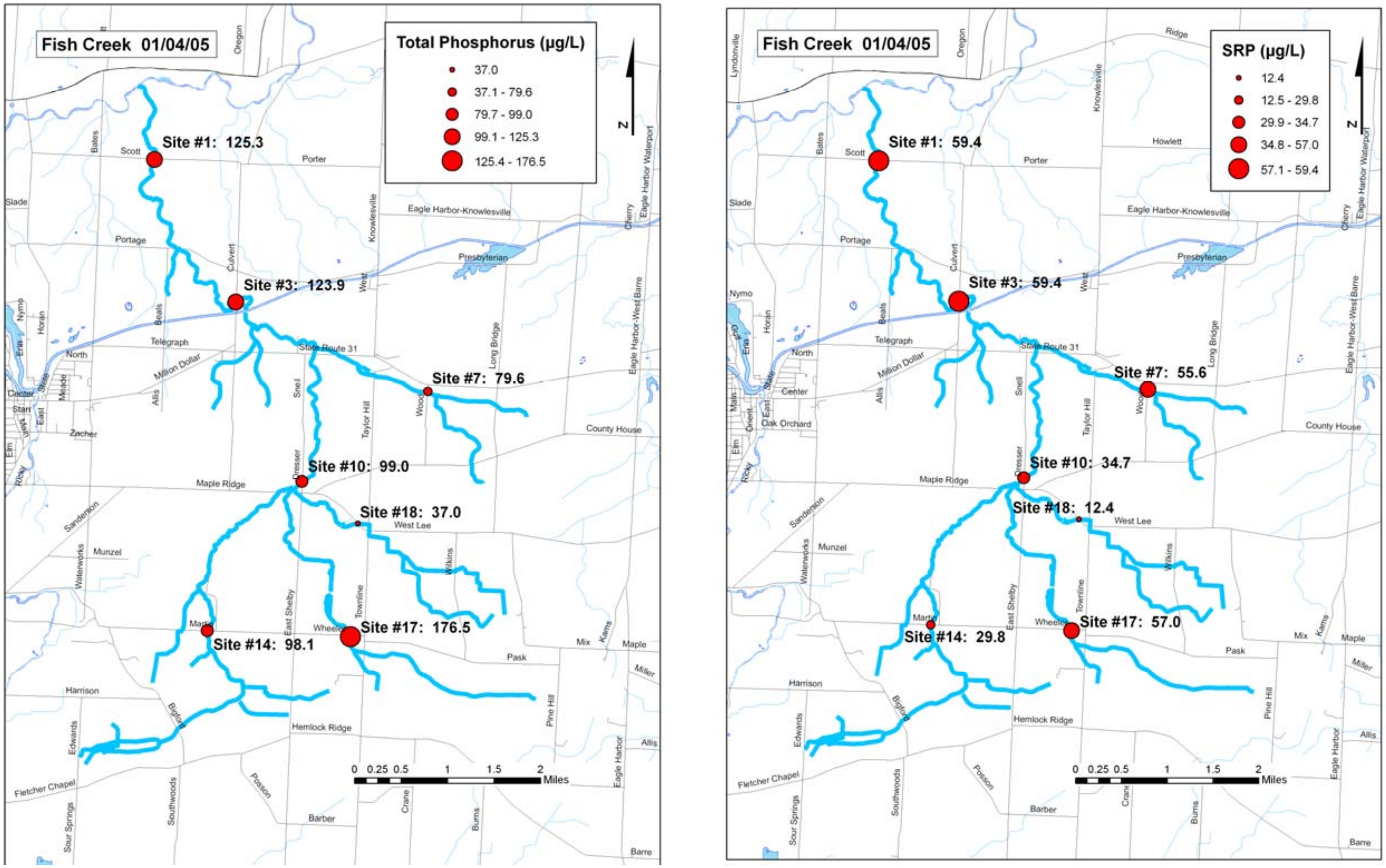


Figure 12. Total phosphorus and soluble reactive phosphorus for Fish Creek on 4 January 2005. The concentration of each parameter is presented next to each site number.

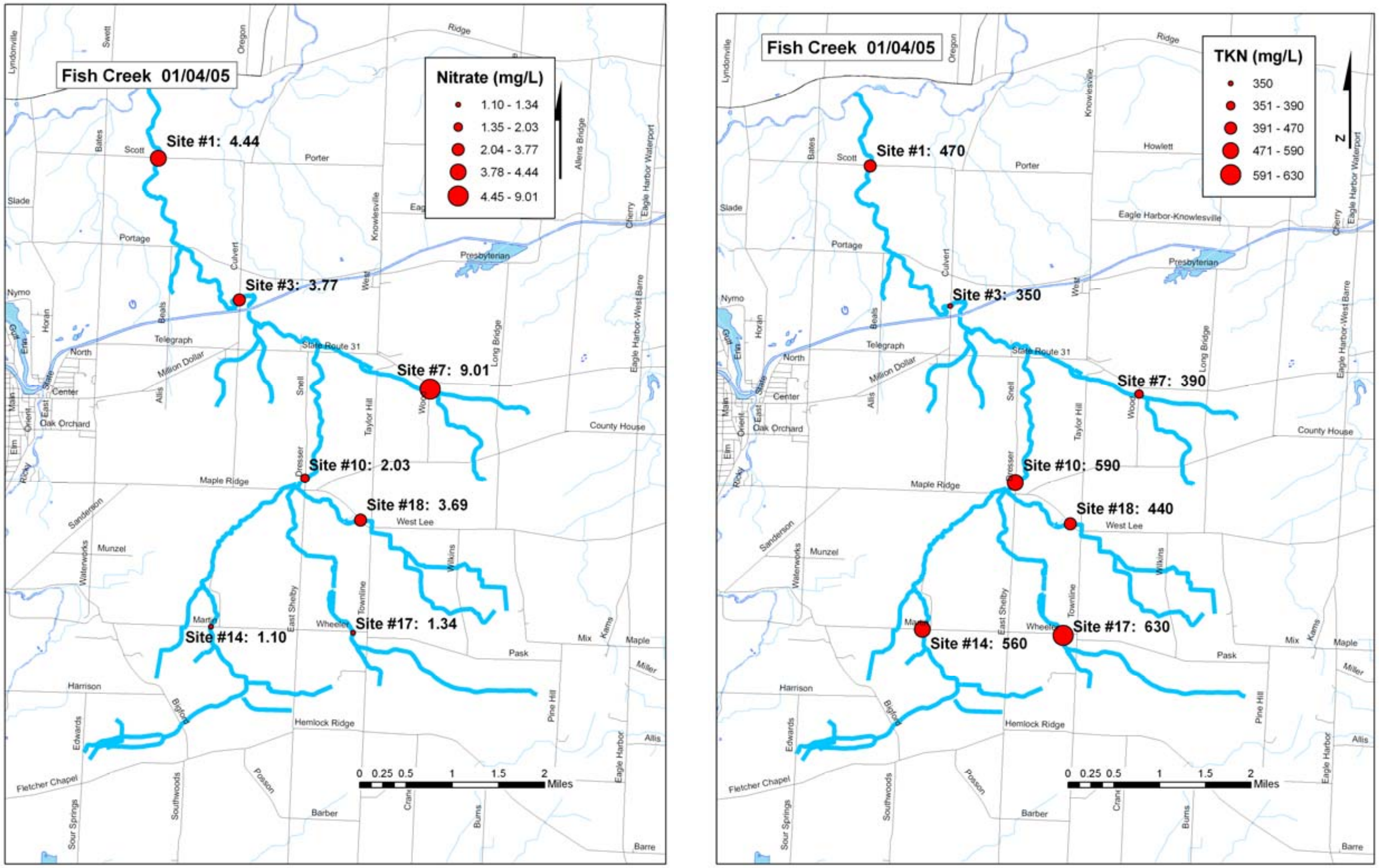
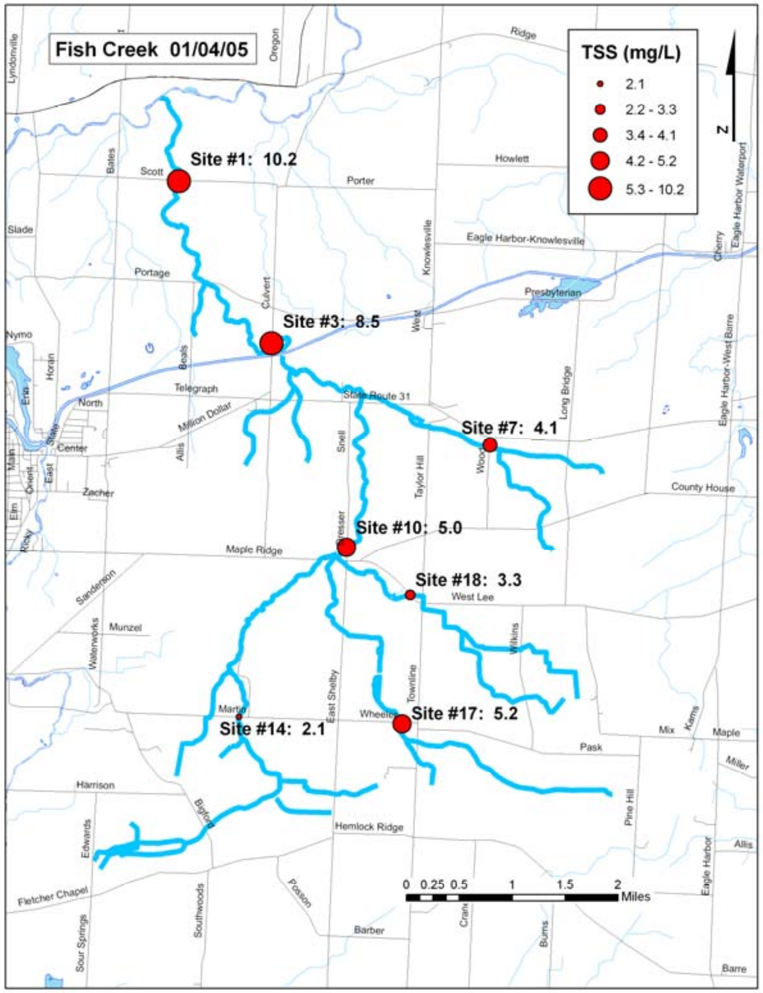


Figure 13. Nitrate and total Kjeldahl nitrogen for Fish Creek on 4 January 2005. The concentration of each parameter is presented next to each site number.



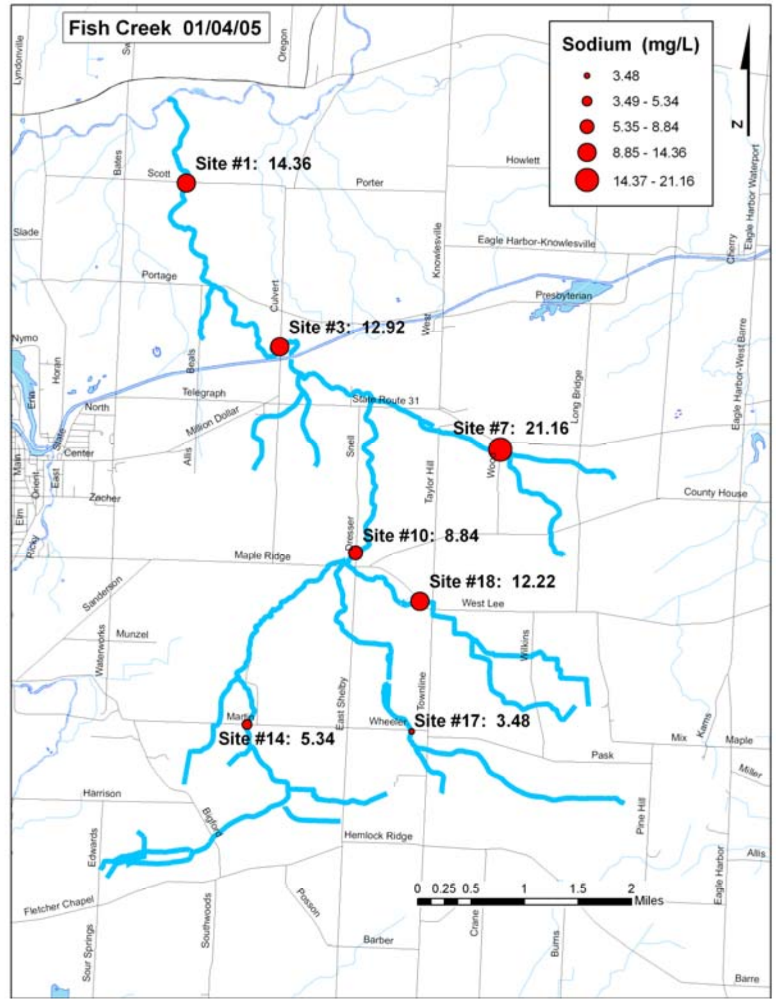


Figure 14. Total suspended solids and sodium for Fish Creek on 4 January 2005. The concentration of each parameter is presented next to each site number.

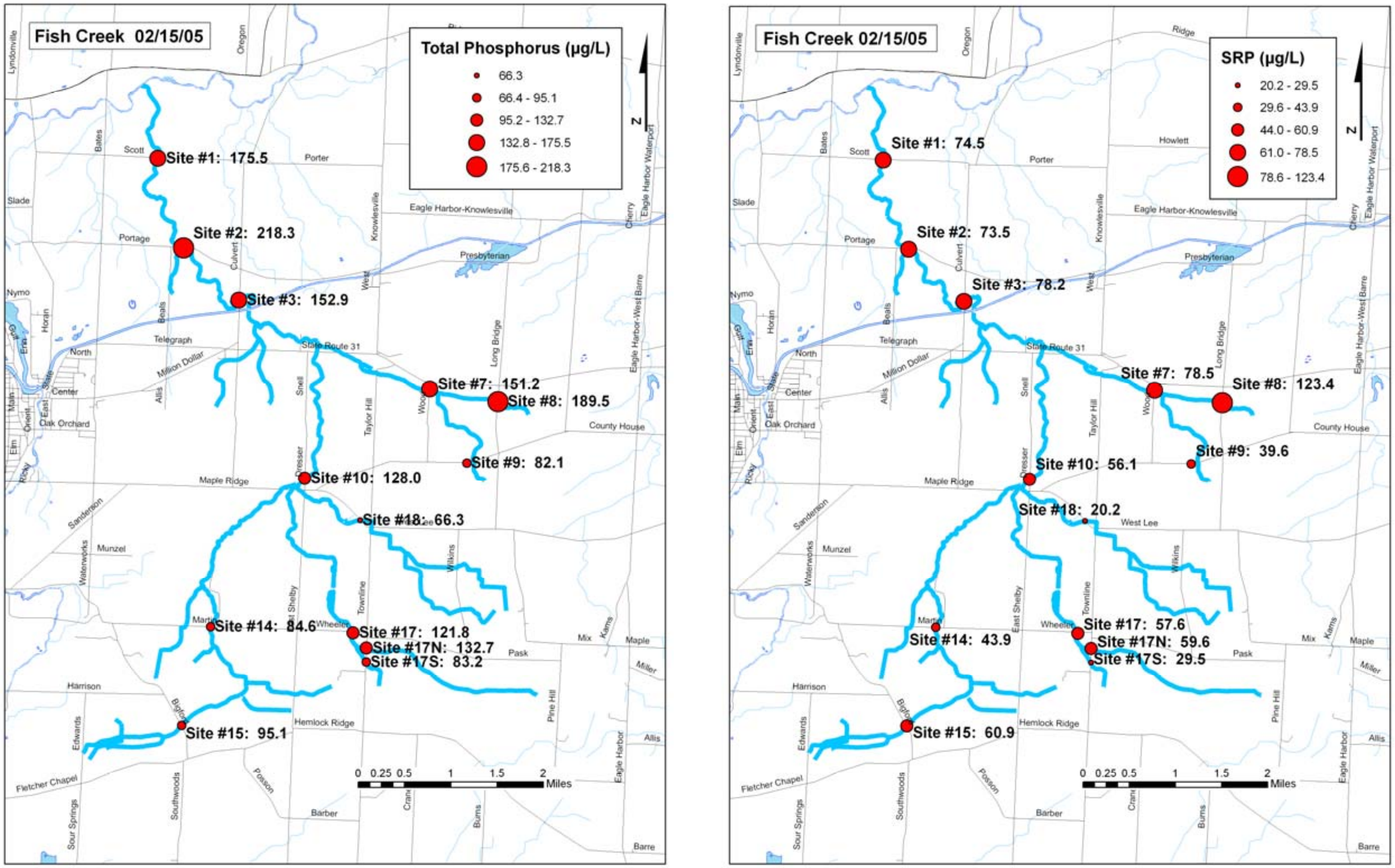
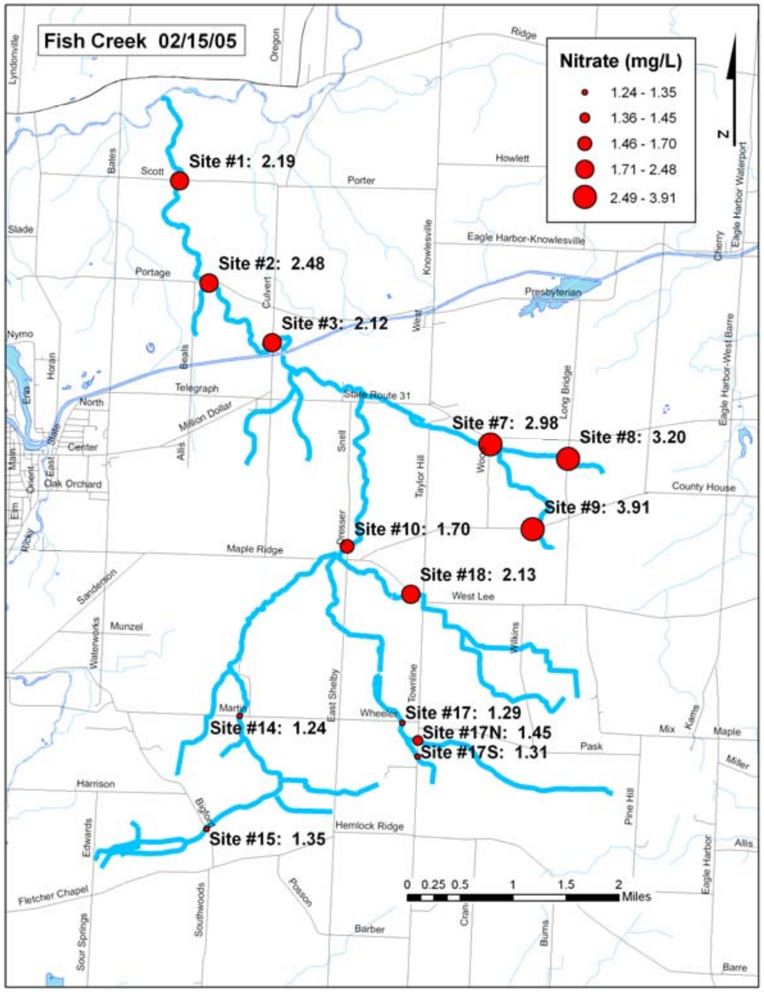


Figure 15. Total phosphorus and soluble reactive phosphorus for Fish Creek on 15 February 2005. The concentration of each parameter is presented next to each site number.



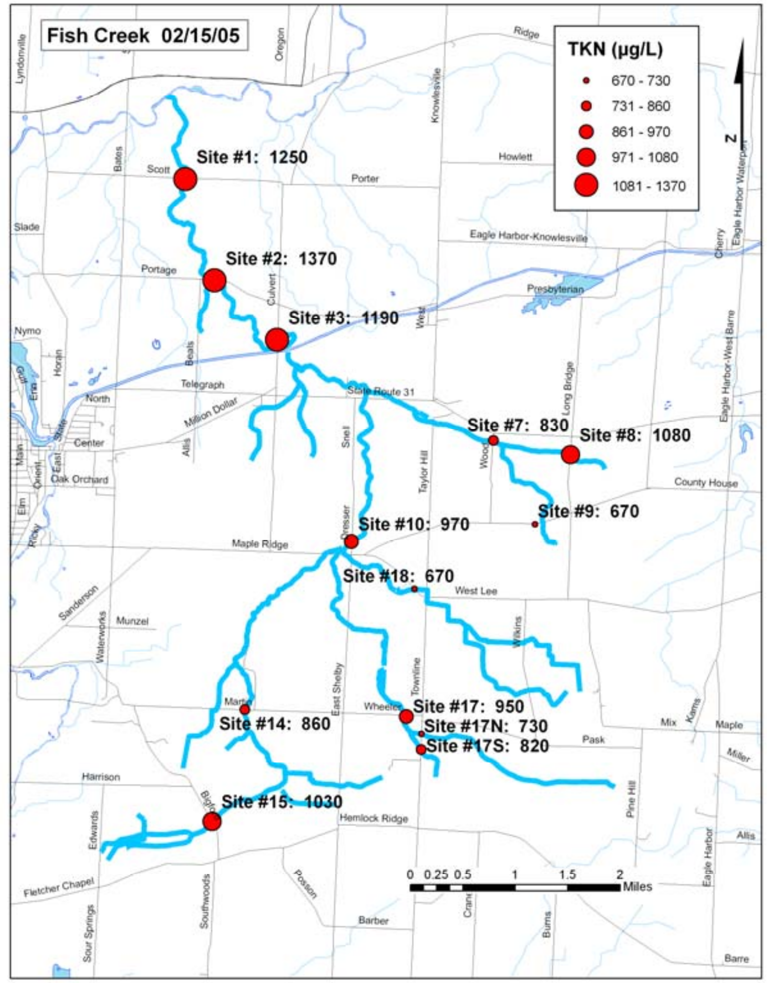
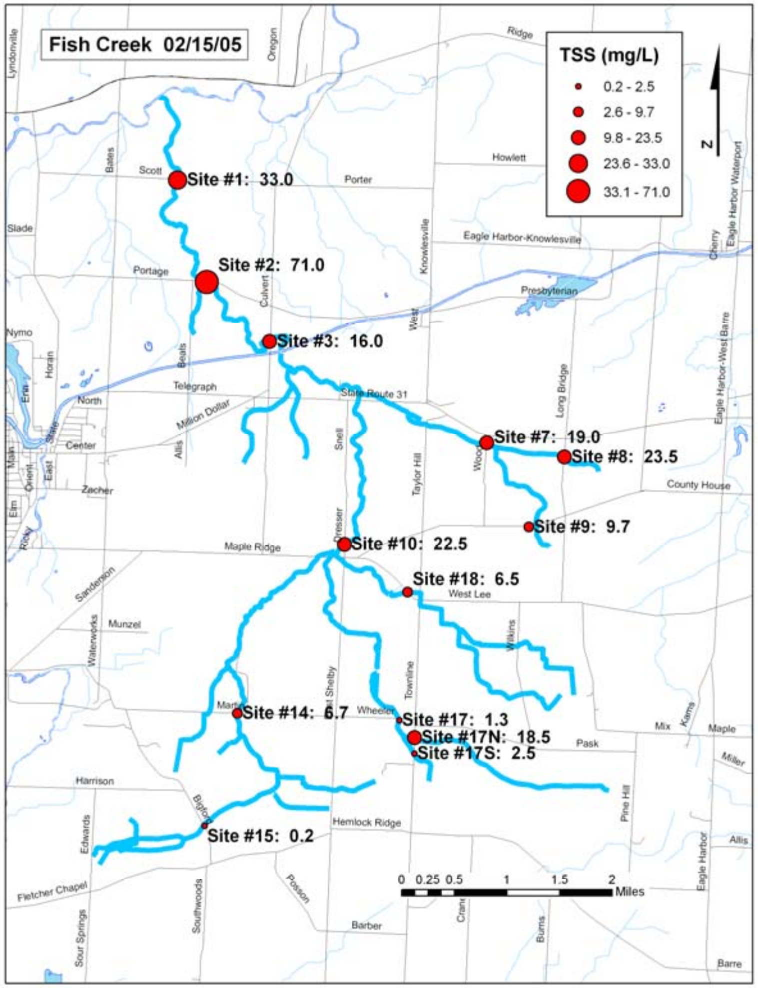


Figure 16. Nitrate and total Kjeldahl nitrogen for Fish Creek on 15 February 2005. The concentration of each parameter is presented next to each site number.



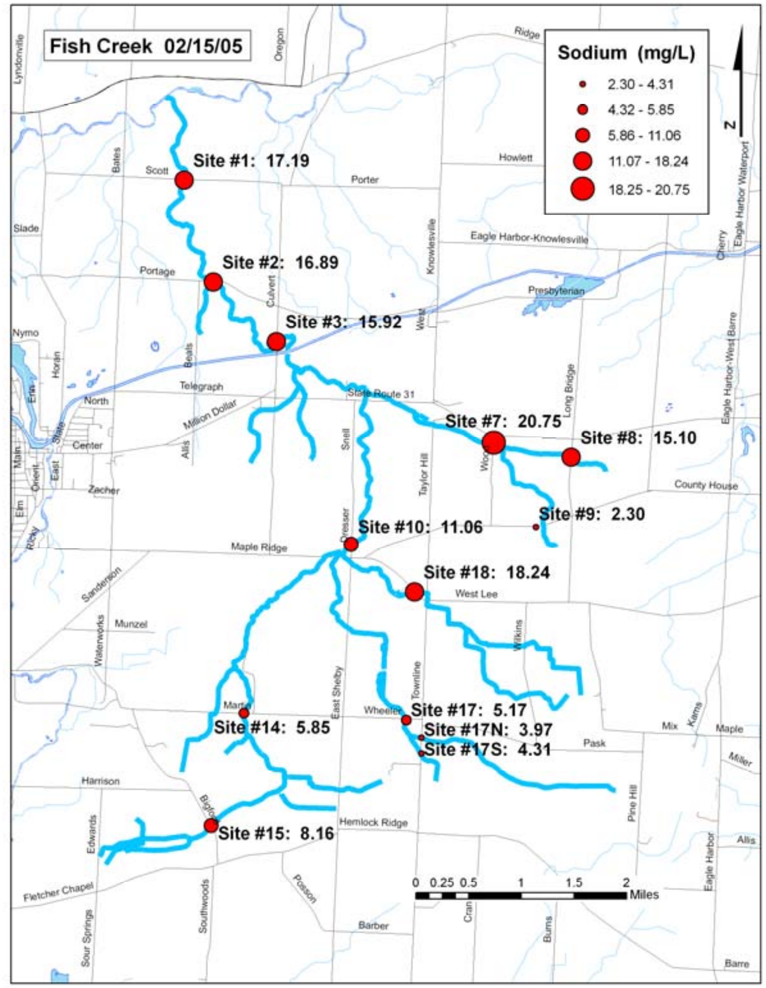


Figure 17. Total suspended solids and sodium for Fish Creek on 15 February 2005. The concentration of each parameter is presented next to each site number.

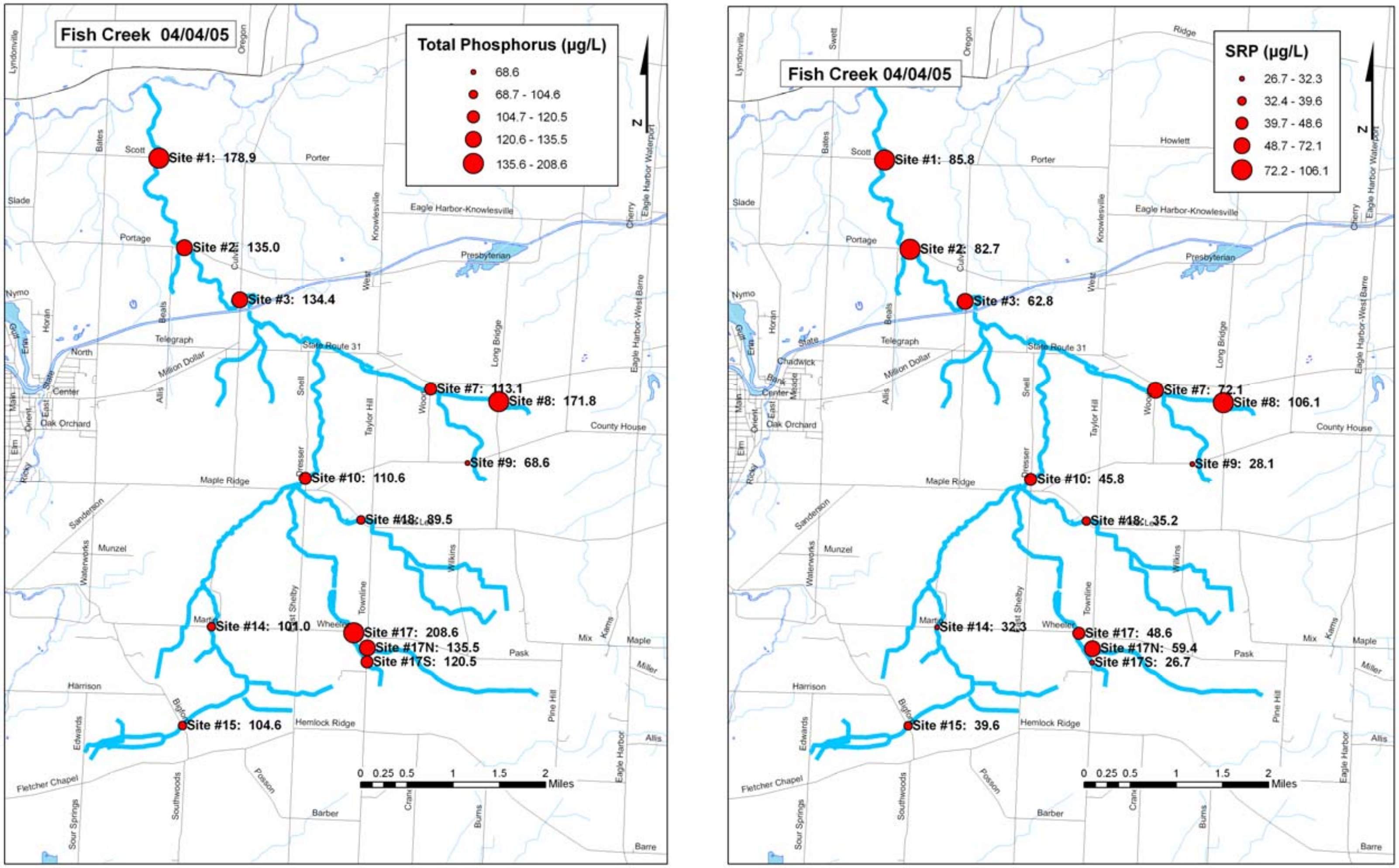


Figure 18. Total phosphorus and soluble reactive phosphorus for Fish Creek on 4 April 2005. The concentration of each parameter is presented next to each site number.

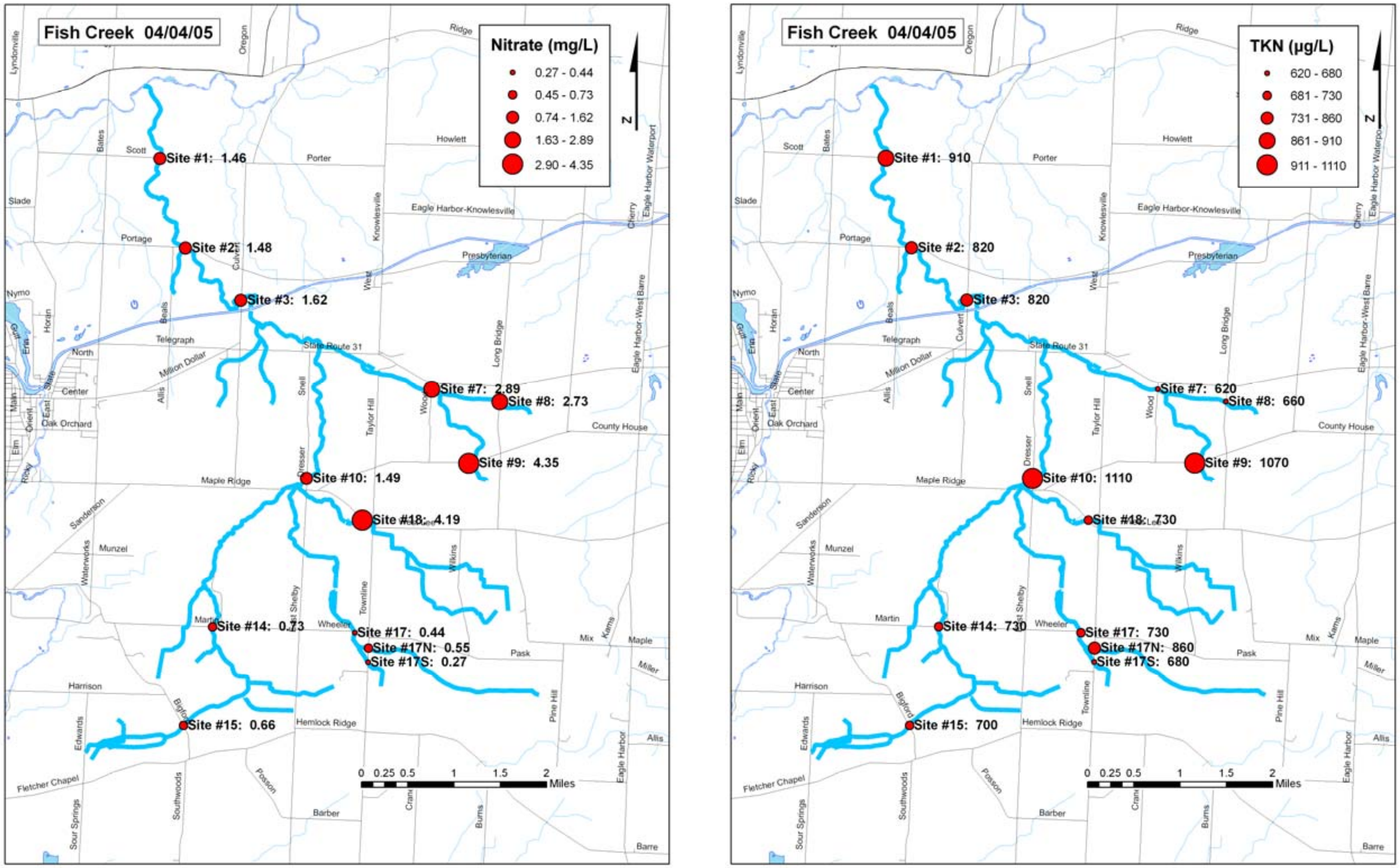
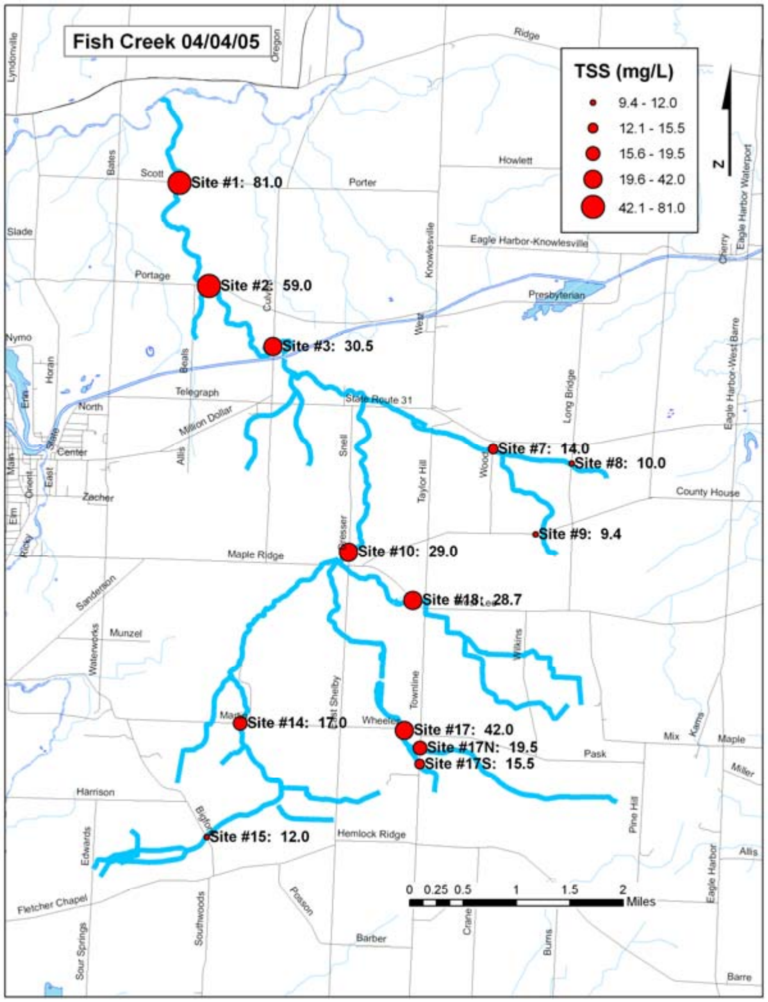


Figure 19. Nitrate and total Kjeldahl nitrogen for Fish Creek on 4 April 2005. The concentration of each parameter is presented next to each site number.



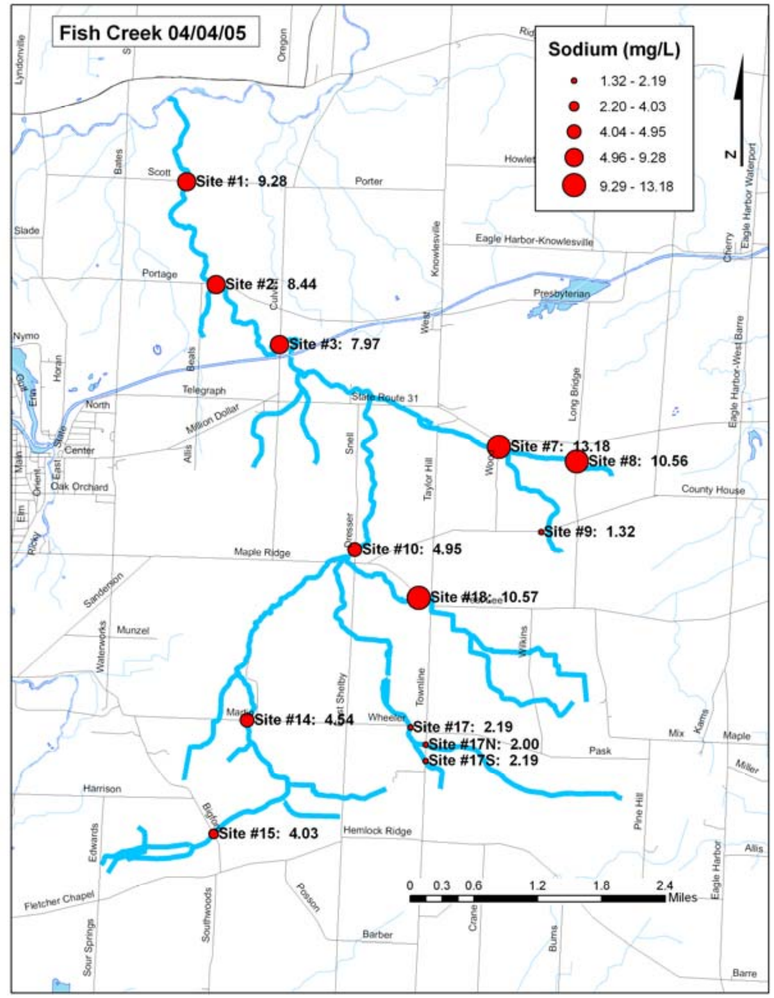
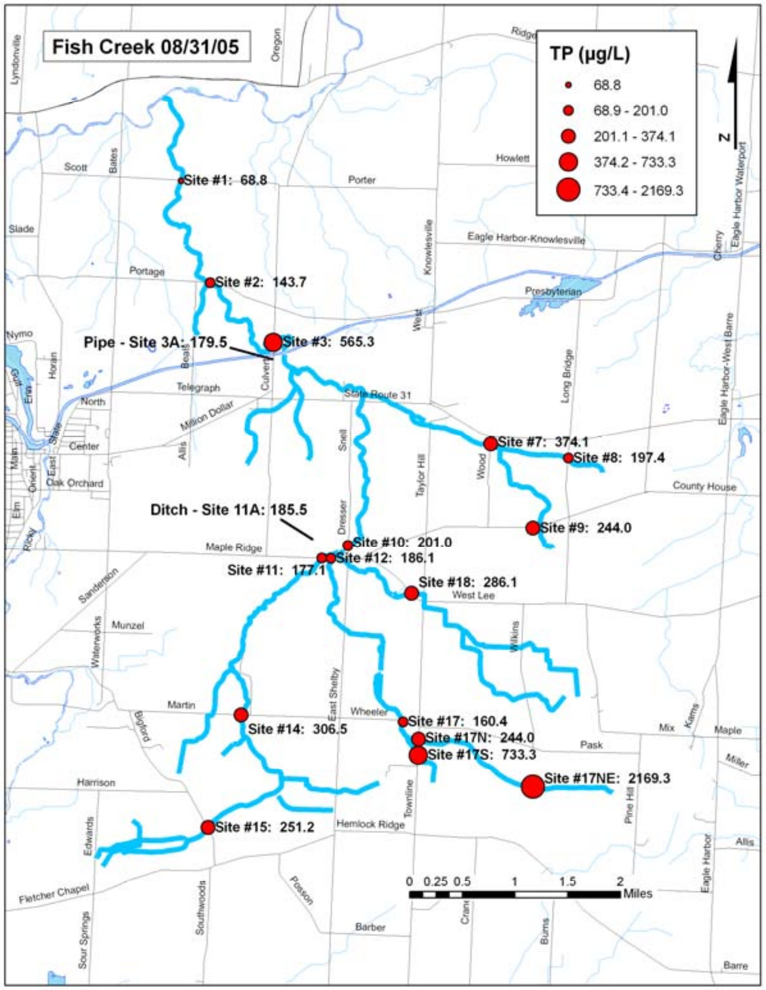


Figure 20. Total suspended solids and sodium for Fish Creek on 4 April 2005. The concentration of each parameter is presented next to each site number.



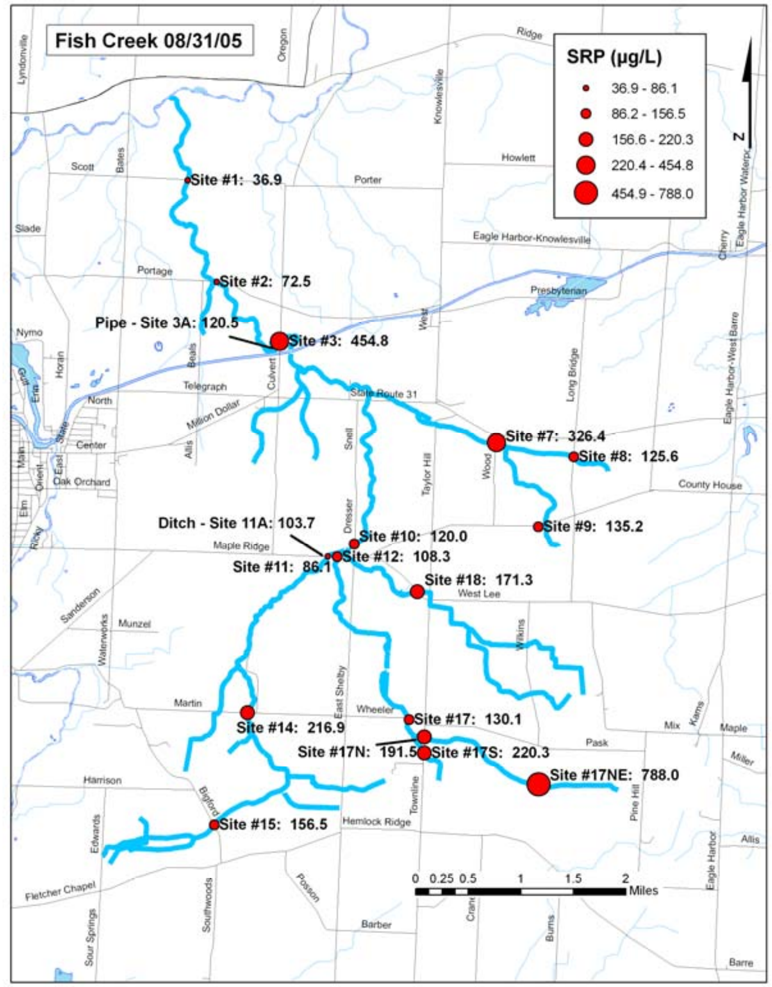
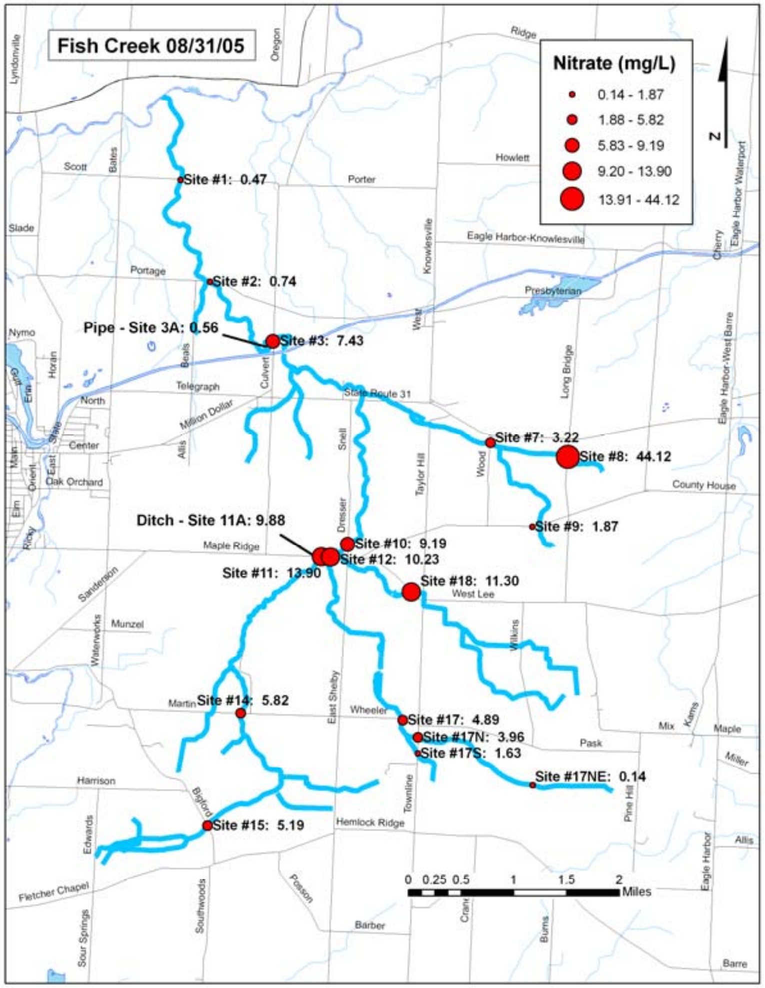


Figure 21. Total phosphorus and soluble reactive phosphorus for Fish Creek on 31 August 2005. The concentration of each parameter is presented next to each site number.



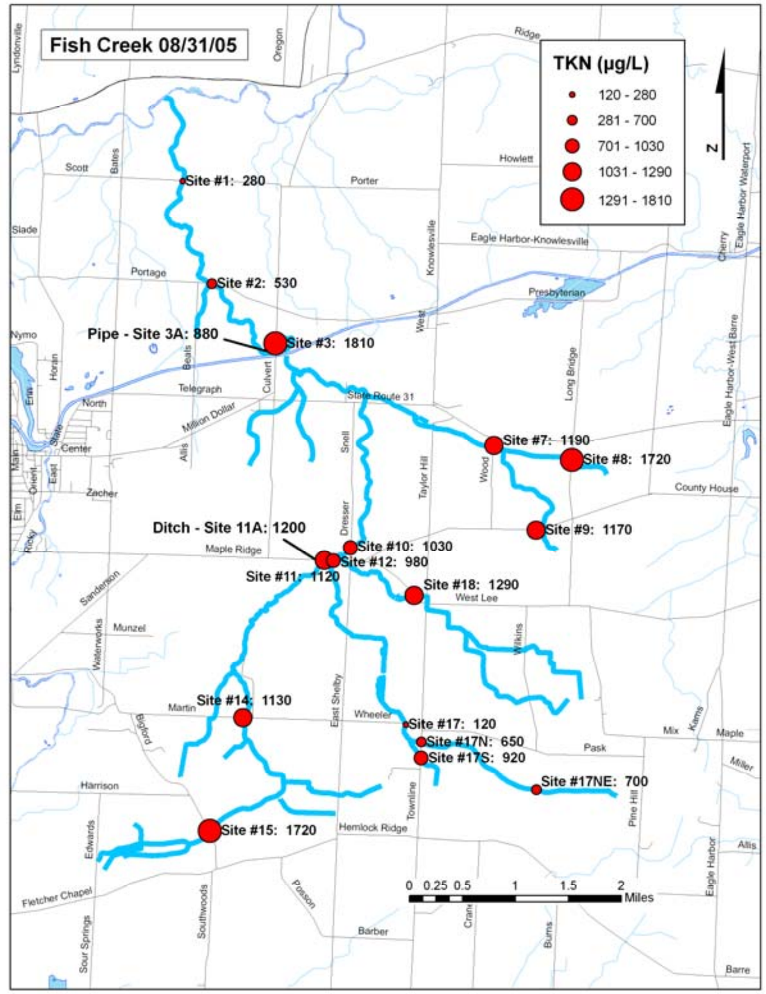
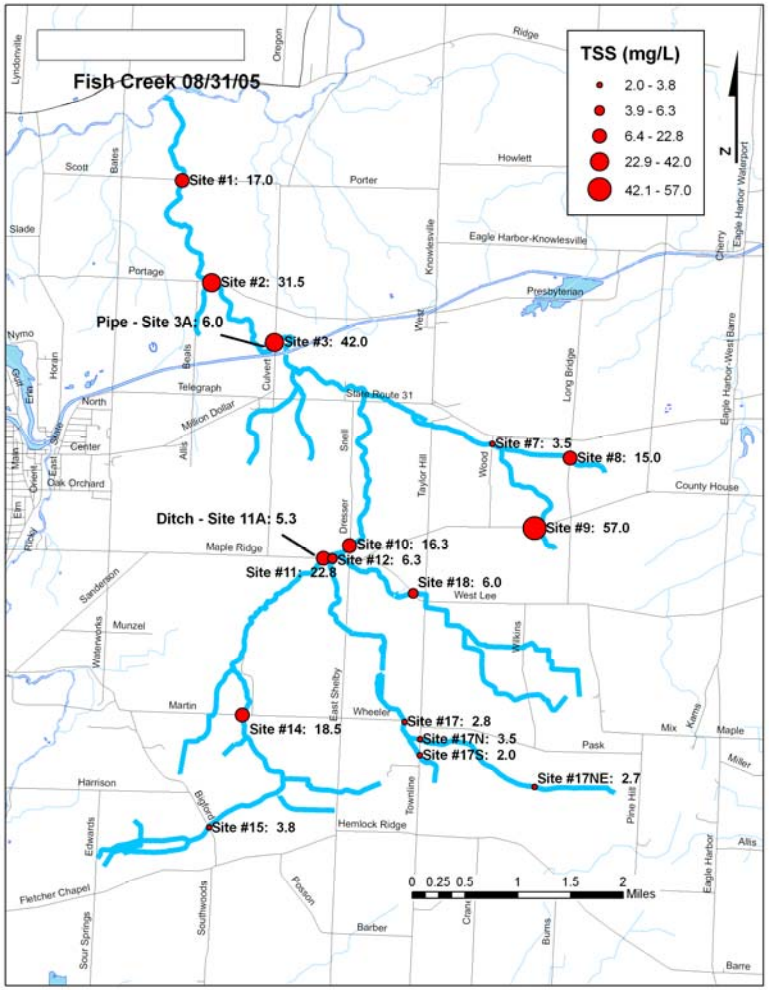


Figure 22. Nitrate and total Kjeldahl nitrogen for Fish Creek on 31 August 2005. The concentration of each parameter is presented next to each site number.



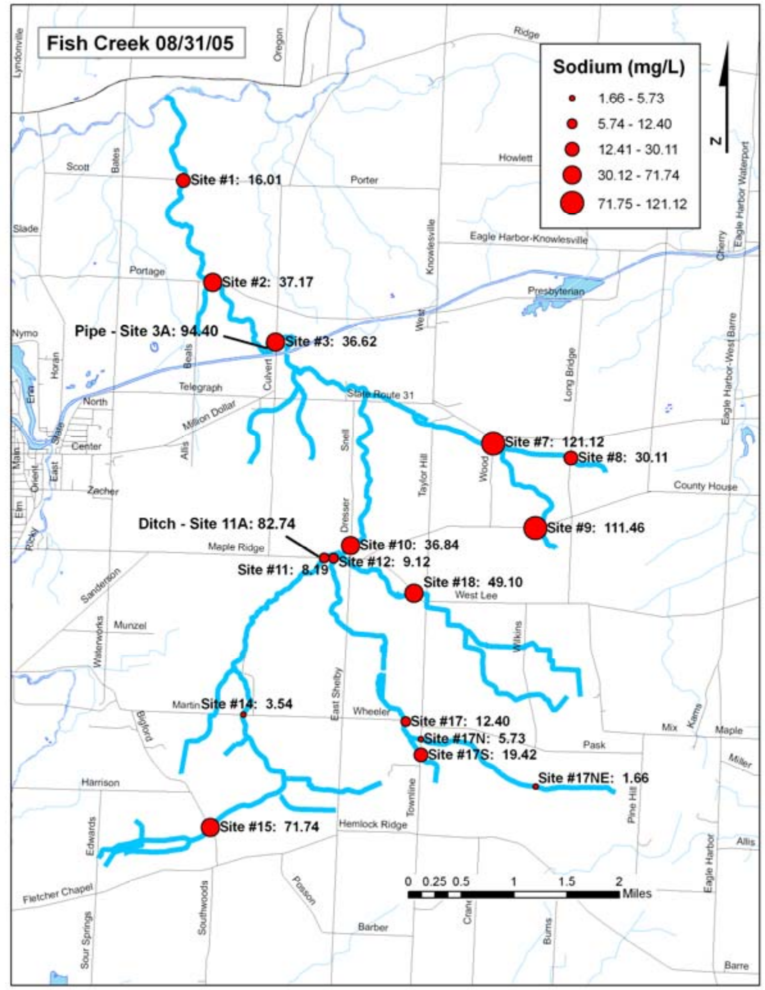


Figure 23. Total suspended solids and sodium for Fish Creek on 31 August 2005. The concentration of each parameter is presented next to each site number.

Appendix A. Farmer Saves Money, Maintains Corn Yields and Retains Soil On His Land!!

Nutrient Reductions to Conesus Lake

Conesus Lake Watershed Project

SUNY Brockport, SUNY Geneseo, Cornell Cooperative Extension

Problem:

Research had demonstrated that large amounts of nutrients and soil were being lost during the winter from the Graywood Creek watershed to Conesus Lake. Soil and nutrient loss is a national concern. Its loss leads to a reduction in crop yields and may lead to increased levels of nutrients in a lake causing blooms of algae and enhanced weed growth.

Management Practices Implemented:

With guidance from Cornell Cooperative Extension, the largest farming operation in the Graywood Creek watershed voluntarily implemented a number of Best Management Practices (BMPs) to address the problems observed. Fertilizer use rates were based on actual soil nutrient tests where credit for manure applications plus nutrient contributions from rotation crops was included. Fall and winter spreading of manure were discontinued in hydrologically sensitive areas and highly erodable land in the watershed in 2003. Strip and cover crops were also planted to reduce erosion on the steep sided slopes of the farm.

Resolution:

The farmer saved over $5000 in purchased fertilizer alone while maintaining crop yields. Just as important, research demonstrated that the amount of nutrients and soil lost from this watershed was significantly reduced by the management program. As Figure 1 demonstrates, significant decreases in total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate, total Kjeldahl nitrogen (TKN) and total suspended solids (TSS) concentrations were realized by 2003 (Figure 1).

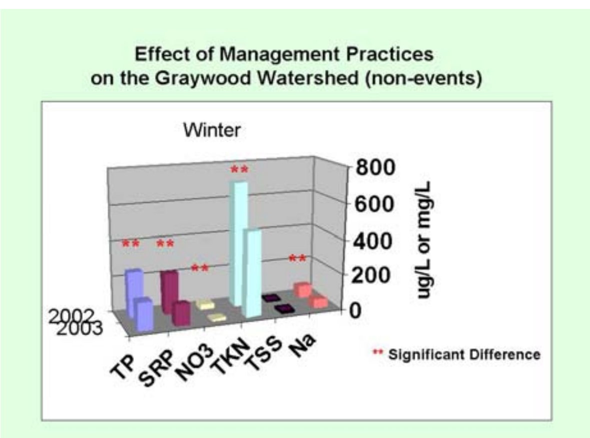


Figure 1. Comparison of winter nutrient and soil loss before and after the establishment of management practices. Total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate (NO_3), total Kjeldahl nitrogen (TKN), total suspended solids (TSS) and sodium (Na).

Background: In the Conesus Lake watershed, several research projects testing various management plans to maintain soil and nutrients on farmland and thus reduce impacts on Conesus Lake have been implemented. Funding was to the State University of New York (SUNY) at Brockport, SUNY Geneseo and Cornell Cooperative Extension from the Cooperative State Research, Education, and Extension Service of the United States Department of Agriculture. With the voluntary cooperation of several farmers within the Conesus Lake watershed, several “Best Management Practices” have been implemented since 2002. These practices include reduction of manure spreading during the winter on steep sided slopes, construction of gully plugs, nutrient reduction, etc. Results on bacteria levels, shore algae and water chemistry are available at the project’s web site http://www.envsci.brockport.edu/Conesus_Project

Soil Loss Reduced From Agricultural Fields After Installation of Gully Plugs

Conesus Lake Watershed Project

SUNY Brockport, SUNY Geneseo, Cornell Cooperative Extension

Problem:
As much as 133 tons of soil per year are lost from the steep slopes of Cottonwood Gully watershed each year and is deposited into Conesus Lake. The problem of soil erosion from watersheds is a national concern because of its potentially negative impact on agriculture because of the physical loss of fertile soil and the resultant reductions in agricultural crop yields. With soil loss, there is also a loss of nutrients that cause blooms of algae and enhance growth of unwanted weeds in lakes.

Management Practices Implemented:
A "cash crop" agricultural operation in the Cottonwood Gully watershed underwent comprehensive nutrient management planning under the Agricultural Environmental Management Program (AEM) in 2002 as part of our USDA sponsored research program. Water And Sediment COntrol Basins (WASCOB or 'gully plugs') were installed in 2003. Gully plugs are basically small dams built into the slope of a hill. These small dams intercept water runoff carrying soil and contain the water and soil into a ponding basin allowing the soil to sediment out while the water is discharged via subsurface drainage to the stream.

Resolution:
In one year, benefits of the Best Management Practices implemented were evident in Cottonwood Gully, where Gully plugs were installed. No reduction in soil loss was evident from "reference" watersheds where gully plugs were not installed. In fact, soil erosion from the watershed (total suspended solids, TSS) was reduced 94% from the previous year (Figure 1). Similarly, more organic nitrogen and phosphorus were retained in the Cottonwood watershed by a factor of 36% and 38%, respectively, within one year of implementation of management plans.

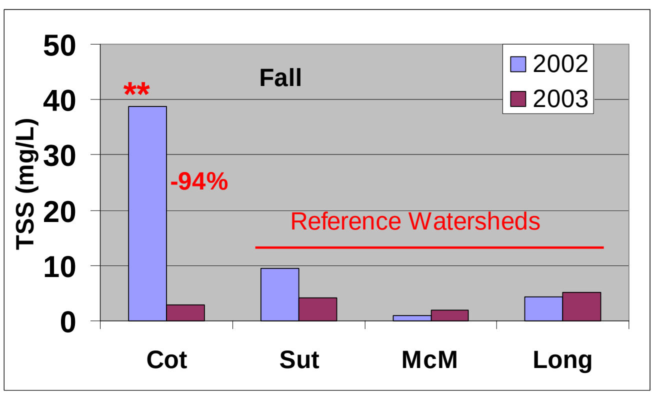


Figure 1. Total suspended solid concentration comparisons from the Fall of 2002 to the Fall of 2003 after implementation of Best Management Practices to Cottonwood Gully (Cot). A significant reduction in soil loss is evident in Cottonwood Gully, but not in the Reference Watersheds of Sutton Point (Sut), North McMillan (McM) and Long Point Gully (Long).

Background:
In the Conesus Lake watershed, several research projects testing various management plans to maintain soil and nutrients on farmland and thus reduce impacts on Conesus Lake have been implemented. Funding was to the State University of New York (SUNY) at Brockport, SUNY Geneseo and Cornell Cooperative Extension from the Cooperative State Research, Education, and Extension Service of the United States Department of Agriculture. With the voluntary cooperation of several farmers within the Conesus Lake watershed, several "Best Management Practices" have been implemented since 2002. These practices include reduction of manure spreading during the winter on steep sided slopes, construction of gully plugs, nutrient reduction, etc. Results on bacteria levels, shore algae and water chemistry are available at the project's web site http://www.envsci.brockport.edu/Conesus_Project